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DEVELOPMENT OF AN AIRCRAFT MANEUVER LOAD SPECTRUM BASED ON VGH DATA

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This report describes a procedure whereby a full scale aircraft maneuver load fatigue spectrum can be developed from recorded VGH data. It is assumed in this development that the internal loads (stresses) at the appropriate control points are available for combinations of velocity, load factor, altitudes and weight so that an interpolation on these points will provide the desired accuracy. The procedure will generate (for a control point) the cumulative probability of exceeding a given stress, exceedances per hour of a given

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stress level, the probability density function for stress and the stress spectrum. The aircraft spectrum is derived from the assumption that the aircraft test loads derived from a linear combination of balanced loading conditions will provide a good simulation of the stress history at and "between" the control points. The application of the program to new designs (mission analysis) and to tracking can be made without modification. The computer program for this calculation is included along with a sample problem. As an example of an application of this program, the stress exceedance functions for a control point on the wing of the F-4 are shown that were computed from the VGH data accumulated over a period of one year.

FOREWARD

This report was prepared by John W. Lincoln, Structures Division of the Directorate of Flight Systems Engineering. The work was done as a research and development task to assist in the spectrum development work for the F-4 durability and damage tolerance assessment.

TABLE OF CONTENTS

LIST OF SYMBOLS

Nv_i	The number of indicated airspeed intervals in the VGH histogram
Nn_z	The number of normal load factor intervals in the VGH histogram
N_h	The number of altitude intervals in the VGH histogram
N_w	The number of weight intervals in the VGH histogram
v_{ii}	Indicated airspeed for the VGH histogram intervals
n_{z_i}	Normal load factor for the VGH histogram intervals
h_i	Altitude for the VGH histogram intervals
w_i	Aircraft weight for the VGH histogram intervals
H_J	The VGH histogram
N_t	The total number of load occurrences in the VGH histogram
P_J	The joint probability density function derived from the VGH histogram
Nv_i^R	The number of intervals in a refinement of an indicated airspeed interval in the VGH histogram
$N_{n_z}^R$	The number of intervals in a refinement of a normal load factor interval in the VGH histogram
N_h^R	The number of intervals in a refinement of an altitude interval in the VGH histogram
N_w^R	The number of intervals in a refinement of a weight interval in the VGH histogram
V_i	A surface, the ordinates of which are indicated airspeeds for determining the stress at a control point
N_z	A surface, the ordinates of which are normal load factors for determining the stress at a control point

H — A surface, the ordinates of which are altitudes for determining the stress at a control point

W — A surface, the ordinates of which are weights for determining the stress at a control point

$\hat{P}_J$ — The joint probability density function for the refined VGH histogram

N_p — The number of control points on the aircraft structure used in the derivation of the fatigue spectrum

$P_{\psi}a$ — The cumulative probability for the stress at the ath control point

$P_{D_{\psi}}a$ — The probability density function for the stress at the ath control point

A^a_{cb} — The stress for the ath load level at the bth point in the sky and the cth control point

Γ^a_c — The fatigue test stress for the ath load level and the cth control point

α^{ab} — Scaling coefficients for the ath load level and the bth point in the sky

Φ^a — A surface (generated from the surface P_J) from which $P_{\psi}a$ can be determined for ath control point

ψ^a — The stress surface for the ath control point

S^a — A set of ordinates of the graph $1 - P_{\psi}a$

$S^a(i)$ — The ith member of S^a

SECTION I

INTRODUCTION

In the application of the mission analysis required by MIL-A-008866A (USAF) to fighter and attack aircraft a problem arises in the selection of the point in the sky (velocity, altitude, and weight) for the load factor spectrum for the combat segment of the mission. It can be shown that in many cases important differences in the spectrum can be obtained from two "reasonable" point selections.

The problem has been particularly severe on some existing aircraft in that a ten percent shift in the stress spectrum can produce a factor of two change in life. Therefore, when it is considered that essentially all of the fatigue damage for fighter and attack aircraft is done in the combat segment, this part of the mission deserves special attention.

From an examination of available VGH data, it is evident that in both the air-to-air and air-to-ground operations a fairly wide variation in velocity, altitude, and weight is observed. Therefore, it would be surprising if a single point in the sky would provide an accurate prediction of the stress spectrum for a control point. This is even more evident for those aircraft which experience non-linearities in the aerodynamic data (i.e., tip stall).

One possible solution is to use multiple points in the sky for this calculation. This can be effectively accomplished by taking the points in the sky and their relative frequency of occurrence that are obtained from that portion of the fleet that is equipped with multichannel recorders (twenty percent of the fleet, which is consistent with current policy, is believed to be an adequate sample). This can be done by taking the VGH histogram (the relative frequency of airspeed, normal load factor, altitude, and weight) and dividing by the total number of load occurrences to obtain the probability that a load will occur in a given interval of airspeed, normal load factor, altitude, and weight. A stress level is selected and a summation is made for each such probability where the corresponding stress at the midpoint of the interval of airspeed, etc, is greater than the selected stress level. This computation produces the cumulative probability of exceeding a stress level. Since the intervals used for the data collection were not designed for this calculation, a provision is made to subdivide the intervals to improve the accuracy of the calculation. This technique is explained in Section III. From the cumulative

probability, the number of stress exceedances per hour, the probability density function, and the stress spectrum can be obtained.

Having the functions referred to above for a number of control points that is adequate to cover the aircraft structure (this number may have to be obtained by trial and error), one may generate the full scale aircraft spectrum by assuming that an arbitrary loading at the control points of the structure can be derived from a linear combination of the loading imposed by balanced load conditions. If N_p control points are used, then N_p balanced load conditions are used to represent the control point load. The use of "representative" balanced load conditions should provide a satisfactory interpolation between control points. These intermediate points should be spot checked against the true spectrum to see if the control point coverage is adequate.

Of course, for a new design, the VGH data does not exist and consequently direct application of this method is impossible. In some cases it will be possible to overcome this difficulty by taking existing VGH data from older aircraft and by use of judgement adapt it to this procedure. In any event, the method should be applied when the proper data becomes available so that by suitable tests and analysis the appropriate changes may be made in the aircraft life predictions.

One important application of this procedure is fighter/attack tracking. The unusual technique is to use the fleet counting accelerometer data and compute the stress for a single point in the sky that is believed to be representative of the particular mission flown (i.e., air-to-air or air-to-ground). In lieu of this approach, one could compute from the VGH data the conditional probability of exceeding a stress given the normal load factor. If this function were available, it would be possible to track to any desired probability on even multiple probability levels depending on what results are desired. This function can be generated from this program by setting all occurrences equal to zero except those that fall in the desired load factor interval. The high positive and low negative load factors may require an extrapolation from neighboring load factors because there may be too few data points to adequately describe these functions.

The program that is discussed in this report is based on the load occurrences in the VGH histogram being dependent on indicated airspeed, normal load factor, altitude, and weight. The stress function is based on the same quantities. An immediate alternate that is

included is to use equivalent load factor instead of load factor. This removes the weight dependency and considerably reduces the magnitude of the input. This option is included in the computer program described in the text. Other alternates that could be obtained by a simple modification of the program are listed as follows:

	VGH data based on	Stress function based on
1.	Indicated airspeed, normal load factor, altitude, and weight.	Mach no., normal load factor, altitude, and weight.
2.	Mach no., normal load factor, altitude, and weight.	Mach no., normal load factor, altitude, and weight.
3.	Equivalent airspeed, normal load factor, and weight	Equivalent airspeed, normal load factor, and weight.

The extension of this program to include other degrees of freedom for the aircraft is immediately evident. The major difficulty is the management of the input data required for the load occurrences and the stress function.

SECTION II

ANALYTICAL DERIVATION OF THE SPECTRUM

The first step in the derivation of the fatigue spectrum is to solve for the stress probability distribution function. This requires that the histogram of occurrences in intervals of indicated airspeed, load factor, altitude, and weight be defined. To do this suppose that each of N_{vi}, N_{n_z}, N_h, and N_w is a positive integer and

(1) v_{ii} is a simple graph such that the x-projection of v_{ii} is the set of integers in $[1, N_{vi} + 1]$ and if i is an integer in $[1, N_{vi} + 1]$ and $i + 1$ is in $[1, N_{vi} + 1]$ then the indicated airspeed $v_{ii}(i)$ is less than the indicated airspeed $v_{ii}(i + 1)$

(2) n_{z_i} is a simple graph such that the x-projection of n_{z_i} is the set of integers in $[1, N_{n_z} + 1]$ and if j is an integer in $[1, N_{n_z} + 1]$ and $j + 1$ is in $[1, N_{n_z} + 1]$ then the normal load factor $n_{z_i}(j)$, is less than the normal load factor $n_{z_i}(j + 1)$

(3) h_i is a simple graph such that the x-projection of h_i is the set of integers in $[1, N_h +1]$ and if k is an integer in $[1, N_h + 1]$ and $k + 1$ is in $[1, N_h + 1]$ then the altitude $h_i(k)$, is less than the altitude $h_i(k + 1)$

(4) w_i is a simple graph such that the x-projection of w_i is the set of integers in $[1, N_w + 1]$ and if m is an integer in $[1, N_w + 1]$ and $m + 1$ is in $[1, N_w + 1]$ the weight $w_i(m)$, is less than the weight $w_i(m + 1)$

Further, suppose H_J is a simple surface such that

$[v_{ii}(i), n_{z_i}(j), h_i(k), w_i(m), H_J(v_{ii}(i), n_{z_i}(j), h_i(k), w_i(m))]$ is a point of H_J *only if*

(1) i is in $[1, N_{vi}]$, j is in $[1, N_{n_z}]$, k is in $[1, N_h]$, m is in $[1, N_w]$ and

(2) $H_J(v_{ii}(i), n_{z_i}(j), h_i(k), w_i(m))$ is the number of "load occurrences" in the rectangular interval $[v_{ii}(i), v_{ii}(i + 1); n_{z_i}(j), n_{z_i}(j + 1); h_i(k), h_i(k + 1); w_i(m), w_i(m + 1)]$ and these load occurrences are assumed to be uniformly distributed within the rectangular interval.

The surface H_J is called the VGH histogram for v_{ii}, n_{z_i}, h_i, and w_i.

The total number of load occurrences included in the VGH histogram H_J is

$$N_t = \sum_{i=1}^{N_{v_i}} \sum_{j=1}^{N_{n_z}} \sum_{k=1}^{N_h} \sum_{m=1}^{N_w} H_J(v_{ii}(i), n_{z_i}(j), h_i(k)k\ w_i(m))$$

Therefore, by definition, the probability that the indicated airspeed, normal load factor, altitude, and weight is in the rectangular interval $[v_{ii}(i), v_{ii}(i + 1); n_{z_i}(j), n_{z_i}(j + 1); h_i(k), h_i(k + 1); w_i(m), w_i(m + 1)]$ is

$$P_J(i,j,k,m) = \frac{H_J(v_{ii}(i), n_{z_i}(j), h_i(k), w_i(m))}{N_t}$$

Now suppose that if i is in $[1, N_{v_i} - 1]$ then the interval $[v_{ii}(i), v_{ii}(i + 1)]$ is covered by $N^R_{v_i}$ equal intervals, if j is in $[1, N_{n_z} - 1]$ then $[n_{z_i}(j), n_{z_i}(j + 1)]$ is covered by $N^R_{n_z}$ equal intervals, if k is in $[1, N_h - 1]$ then $[h_i(k), h_i(k + 1)]$ is covered by N^R_n equal intervals, and if m is in $[1, N_w - 1]$ then $[w_i(m), w_i(m + 1)]$ is covered by N^R_w equal intervals.

Since it was supposed that the load occurrences are within the rectangular interval $[v_{ii}(i), v_{ii}(i + 1); n_{z_i}(j), n_{z_i}(j + 1); h_i(k), h_i(k + 1); w_i(m), w_i(m + 1)]$ then the probability that the indicated airspeed, normal load factor, altitude, and weight is in the rectangular interval

$$[v_{ii}(i), v_{ii}(i) + \frac{v_{ii}(i + 1) - v_{ii}(i)}{N^R_{v_i}};$$

$$n_{z_i}(j), n_{z_i}(j) + \frac{n_{z_i}(j + 1) - n_{z_i}(j)}{N^R_{n_z}};$$

$$h_i(k), h_i(k) + \frac{h_i(k + 1) - h_i(k)}{N^R_h};$$

$$w_i(m), w_i(m) + \frac{w_i(m + 1) - w_i(m)}{N^R_w}]$$

is

$$\hat{P}_J(i, j, k, m) = \frac{H_J(v_i(i), n_z(j), h(k), w(m))}{N_t N^R_{v_i} N^R_{n_z} N^R_h N^R_w}$$

(1) Now suppose that V_i is a simple surface such that the x-y projection of V_i is the set of integers in the rectangular

interval $[1, N_{v_i} + 1; 1, N^R_{v_i}]$ and if i and i + 1 are ingers in $[1, N_{v_i} + 1]$ and i_R is an integer in $[1, N^R_{v_i}]$ then

$$V_i(i, i_R) = v_{ii}(i) + \left(\frac{i_R - 0.5}{N^R_{v_i}}\right)(v_{ii}(i + 1) - v_{ii}(i))$$

(2) N_z is a simple surface such that the x-y projection of N_z is the set of integers in the rectangular interval $[1, N_{n_z} + 1; 1, N^R_{n_z}]$ and if j, and j+ 1 are integers in $[1, N_{n_z} + 1]$ and jr is an integer in $[1, N^R_{n_z}]$ then

$$N_z(j, j_R) = n_{z_i}(j) + \left(\frac{j_R - 0.5}{N^R_{n_z}}\right)(n_{z_i}(j + 1) - n_{z_i}(j))$$

(3) H is a simple surface such that the x, y projection of H is the set of integers in the rectangular interval $[1, N_h + 1; 1, N^R_h]$ and if k and k + 1 are integers in $[1, N_h + 1]$ and k_R is an integer in $[1, N^R_h]$ then

$$H(k, k_R) = h_i(k) + \left(\frac{k_R - 0.5}{N^R_h}\right)(h_i(k + 1) - h_i(k))$$

(4) W is a simple surface such that the x, y projection of W is the set of integers in the rectangular interval $[1, N_w + 1; 1, N^R_w]$ and if m and m + 1 are integers in $[1, N_w + 1]$ and m_R is an integer in $[1, N^R_w]$ then

$$W(m, m_R) = w_i(m) + \left(\frac{m_R - 0.5}{N^R_w}\right)(w_i(m + 1) - w_i(m))$$

The assumption is made that the stress at a point in the structure depends only on the indicated airspeed, normal load factor, altitude and weight. Therefore, if it is supposed that each of a and N_p is a positive integer such that a is in $[1, N_p]$

and Ψ^a is a simple surface such that $(V_i(i,i_R), N_z(j,j_R), H(k,k_R), W(m,m_R), \Psi^a(V_i(i,i_R), N_z(j,j_R), H(k,k_R), W(m,m_R))$ is a point of Ψ^a only if i is in $[1,N_{V_i} + 1]$, i_R is in $[1,N^R_{V_i}]$, $\cdots$,m is in $[1,N_w + 1]$, m_R is in $[1,N^R_w]$ and $\Psi^a(V_i(i,i_R), N_z(j,j_R), H(k,k_R), W(m,m_R))$ is the stress for the ath control point corresponding to the indicated airspeed $V_i(i,i_R)$, the normal load factor $N_z(j,j_R)$, the altitude $H(k,k_R)$, and the weight $W(m,m_R)$.

The surfaces Ψ^a and $\hat{P}_J$ are used in the calculation of the cumulative probability of exceeding a given stress as follows: Suppose that N_{Γ_L} is a positive integer and Γ_L is a uniformly increasing sequence with x-projection $[1,N_{\Gamma_L}]$ and Φ^a is a simple surface such that

(1) $\Phi^a\ (i,j,k,m,i_R, j_R,k_R,m_R) = \hat{P}_J(i,j,k,m)$
if $\Psi^a(V_i(i,i_R), N_z(j,j_R), H(k,k_R), W(m,m_R)) > \Gamma_L(b)$

(2) $\Phi^a(i,j,k,m,i_R,j_R,k_R,m_R) = 0$
if $\Psi^a(V_i(i,i_R),N_z(j,j_R),H(k,k_R),W(m,m_R)) \leq \Gamma_L(b)$

Therefore, the probability that the stress is greater than $\Gamma_L(b)$ is

$$P_\Psi a(\Gamma_L(b)) = \sum_{i=1}^{N_{V_i}} \sum_{j=1}^{N_{n_z}} \sum_{k=1}^{N_h} \sum_{m=1}^{N_w} \sum_{i_R=1}^{N^R_{V_i}} \sum_{j_R=1}^{N^R_{n_z}} \sum_{k_R=1}^{N^R_h} \sum_{m_R=1}^{N^R_w}$$

$$\Phi^a(i,j,k,m,i_R,j_R,k_R,m_R)$$

The probability density function $P_{D_\Psi a}$ is the derivative of the cumulative probability function $P_\Psi a$. This derivative is computed as follows: Suppose a is an integer in $[1,N_p]$ and that ζ^a is a simple graph with x-projection the interval $[1,N_{\Gamma_L}]$ such that

(1) if b is an integer in $[1, N_{\Gamma_L}]$ then $\zeta^a(b) = P_\psi a(b)$ and

(2) if c is a number in $[b, b + 2]$ there exists a u_1, u_2, and u_3 such that $\zeta^a(c) + u_1 c^2 + u_2 c + u_3$ where u_1, u_2, u_3 are determined from the equations

$$\begin{matrix} \zeta^a(b) \\ \zeta^a(b+1) \\ \zeta^a(b+2) \end{matrix} = \begin{matrix} b^2 & b & 1 \\ (b+1)^2 & (b+1) & 1 \\ (b+2)^2 & (b+2) & 1 \end{matrix} \begin{matrix} u_1 \\ u_2 \\ u_3 \end{matrix}$$

Therefore

(1) if $b = 1$

$$P_{D_\psi a}(1) = 2u_1 \; \Gamma_L(1) + u_2$$

$$P_{D_\psi a}(2) = 2\,u_1 \; \Gamma_L(1) + u_2$$

(2) if b is in $[2, N_{\Gamma_L} - 3]$

$$P_{D_\psi a}(b + 1) = 2\,u_1 \; \Gamma_L(b + 1) + u_2$$

(3) if $b = N_{\Gamma_L} - 2$

$$P_{D_\psi a}(N_{\Gamma_L} - 1) = 2\,u_1 \; \Gamma_L(N_{\Gamma_L} - 1) + u_2$$

$$P_{D_\psi a}(N_{\Gamma_L}) = 2\,u_1 \; \Gamma_L(N_{\Gamma_L}) + u_2$$

The next step in the derivation of the fatigue loading spectrum is to determine the stress and the frequency of that stress in the spectrum. This is done by an indirect process as shown below. Suppose that the fatigue test spectrum is to be composed of N cycles at M stress levels. Further, suppose that a is a positive integer in $[1, N_p]$ and S^a is a sequence of M numbers such that $s^a(i)$ and $s^a(j)$ are members of S^a only if $0 < s^a(i) < s^a(j) < 1$ and $i < j$.

Therefore, each member of S^a corresponds to an ordinate of the graph $1-P_\psi a$. The M abscissas corresponding to these M ordinates are defined as the M stress levels of the spectrum for the ath control point. The graph $1-P_\psi a$ is known at N_{Γ_L} points. Consequently, an approximation to $1-P_\psi a$ must be found in order to compute the spectrum stress levels. Suppose β is a simple graph with x-projection the interval $[\Gamma_L(1), \Gamma_L(N_{\Gamma_L})]$ and if k is in $[1, N_{\Gamma_L}]$ then $\beta(\Gamma_L(k)) = 1-P_\psi a(\Gamma_L(k))$. Further, suppose that if i-1, i, and i + 1 are in $[1, N_{\Gamma_L}]$, δ_L is $\Gamma_L(k+1) - \Gamma_L(k)$, and x is in $[-\delta_L, \delta_L]$ then

$$\beta(x + \Gamma_L(k)) = \left[1 \ \frac{x}{\delta_L} \ \left(\frac{x}{\delta_L}\right)^2\right] \begin{pmatrix} 0 & 1 & 0 \\ -\frac{1}{2} & 0 & \frac{1}{2} \\ \frac{1}{2} & -1 & \frac{1}{2} \end{pmatrix} \begin{pmatrix} \beta(\Gamma_L(k-1)) \\ \beta(\Gamma_L(k)) \\ \beta(\Gamma_L(k+1)) \end{pmatrix}$$

It follows then that if i is in [1,M) there exists an integer k such that $P_\psi a(\Gamma_L(k-1)) \leq s^a(i) \leq P_\psi a(\Gamma_L(k))$ and a number x such that $\beta(x + \Gamma_L(k)) = s^a(i)$. The number x is obtained from a solution of a quadratic equation and $x + \Gamma_L(k)$ is the stress corresponding to $s^a(i)$.

The fraction of the N cycles, n_i, that are associated with the ith stress level is defined as follows:

$$n_1 = \frac{s(1) + s(2)}{2}$$

$$n_i = \frac{s(i+1) - s(i-1)}{2} \qquad 1 < i < M$$

$$n_M = 1 - \frac{(s(M) + s(M-1))}{2}$$

It follows then that if i is in [1,M] and if the sequence S^a is used for each of the control points then there will be an equal number of loading cycles for the ith load level for each of the control points.

The final step is to determine a set of coefficients which when multiplied by the stresses corresponding to balanced load conditions for the aircraft will produce the desired stress levels at the aircraft control points. Suppose a is a positive integer in [1,M], b is a positive integer in [1, N_p], and c is a positive integer in [1,N_p]. Therefore, if A^a_{cb} is the stress for the ath load level at the bth point in the sky and the cth control point and Γ^a_c is the stress desired in the fatigue test for the ath load level and the cth control point then there exists a set of coefficents α^{ab} such that $\Gamma^a_c = A^a_{cb}\ \alpha^{ab}$.

SECTION III

DESCRIPTION OF THE COMPUTER PROGRAM

1 NOTATION

The right hand side of the following relations are defined in Section II.

NT421 = N_{v_i}

NT422 = N_{n_z}

NT423 = N_h

NT424 = N_w

NT = N_t

PJT = $\hat{P}_J$

NRVI = $N^R_{v_i}$

NRNZ = $N^R_{n_z}$

NRH = N^R_h

NRW = N^R_w

VII = v_{ii}

NZI = n_{z_i}

HI = h_i

WI = w_i

VI = V_i

NZ = N_z

H = H

W = W

NPS = N_p

PPSI = $P_\psi a$ (The a is not explicitly identified in the program)

PDPSI = $P_{D_\psi a}$ (The a is not explicitly identified in the program)

PS = A

PLD = Γ
ALPHA = α
FVI = $v_{ii}(N_{v_i} + 1)$
FNZ = $n_{z_i}(N_{n_z} + 1)$
FH = $h_i(N_h + 1)$
FW = $w_i(N_w + 1)$
FACTØR - Stress scaling factor. FACTØR = 1 unless otherwise specified.
HØURS - The number of hours of data in the VGH histogram
PSIL = Γ_L
AREAN = s^a
DELTA = δ_L
APDPSI(I) = 1.0 - PPSI(I)
PSILL (I) - The stress level that is the abscissa of the point of PPSI whose ordinate is AREAN(I)
FRAC(I) - The fraction of the total number of cycles in the spectrum that correspond to PSILL
NPSIL = N_{Γ_L}
NPSILL = M
EXCEED(I) - The number of exceedances per hour of the stress PSIL(I)
NZERO - Control number to zero the input numbers at the start of a run and then prevent them from being zeroed between cases
NPSCT - Control number for counting the number of control points for which a spectrum has been computed in a single run

2 INTERPOLATION PROCEDURE

Since the stress is initially calculated for only a finite set of points on the stress surface, an assumption must be made to determine the stress for a given indicated airspeed, normal load factor, altitude, and weight. Specifically, the problem may be expressed as follows: Given that NT421, NT422, NT423, NT424, NRVI, NRNZ, NRH, and NRW is a positive integer and I is in [1,NT421], J is in [1,NT422], K is in [1,NT423], M is in [1,NT424], IR is in [1,NRVI], JR is in [1,NRNZ], KR is in [1,NRH], MR is in [1,NRW] and a is in $[1,N_p]$ it is required to create an approximation in the form

$\xi^a(I,J,K,M,IR,JR,KR,MR) =$

$\Xi^a(VI(I,IR),NZ(J,JR),H(K,KR),W(M,MR))$

for the stress as expressed by

$\psi^a(I,J,K,M,IR,JR,KR,MR) =$

$\Psi^a(VI(I,IR),NZ(J,JR),H(K,KR),W(M,MR))$

where Ξ^a is a ruled surface based on $2^4 = 16$ points of Ψ^a. The method of choosing these 16 points and the calculation of the stress approximation is described below.

The first step is to define the function TABLE which contains the projections and ordinates of the Ψ^a surface.

Suppose each of NTAB1, NTAB2, NTAB3, and NTAB4 is a positive integer and that

NN12 = NTAB1 + NTAB2
NN13 = NN12 + NTAB3
NN14 = NN13 + NTAB4
NP = NTAB1 · NTAB2 · NTAB3 · NTAB4
NF = NN14 + NP

Further, suppose that TABLE is a simple graph such that the x-projection of TABLE is the set of integers in the interval [1,NF] and each of I1, I2, I3, and I4 is a positive integer.

Also,

(1) if I1 and I1 + 1 are in [1,NTAB1] then the indicated airspeed TABLE (I1) is less than the indicated airspeed TABLE (I1 + 1)

(2) if I2 and I2 + 1 are in [NTAB1 + 1, NN12] then the normal load factor TABLE (I2) is less than the normal load factor TABLE (I2 + 1)

(3) if I3 and I3 + 1 are in [NN12 + 1, NN13] then the altitude TABLE (I3), is less than the altitude TABLE (I3 + 1)

(4) if I4 and I4 + 1 are in [NN13 + 1, NN14] then the weight TABLE (I4) is less than the weight TABLE (I4 + 1)

(5) if I1 is in [1,NTAB1], I2 is in [NTAB1 + 1, NN12], I3 is in [NN12 + 1, NN13], I4 is in [NN13 + 1, NN14]

and n is in [NN14 + 1, NF] and is equal to NN14 + (I4 - NN13 - 1) · NTAB3 · NTAB2 · NTAB1 + (I3 - NN12 - 1) - NTAB2 · NTAB1 + (I2 - NTAB1 - 1) · NTAB1 + I1 then the stress TABLE (n) is the stress that corresponds to the indicated airspeed TABLE (I1), the normal load factor TABLE (I2), the altitude TABLE (I3) and the weight TABLE (I4).

The positive integers I1, I2, I3, and I4 are determined as follows: A search is made for the integer i that will determine the smallest number TABLE (i) that equals or exceeds VI(I,IR). If i = 1 satisfies this requirement then I1 is set equal to 2. If i is in [2, NTAB1] then I1 is set equal to i. If no i can be found in [2, NTAB1] then I1 is set equal to NTAB1. A search is made for the integer j that will determine the smallest number TABLE (j) that equals or exceeds (NZ(J,JR). If j = NTAB1 + 1 then I2 is set equal to NTAB1 + 2. If j is in [NTAB1 + 2, NN12] then I2 is set equal to j. If no j can be found to satisfy the requirement then I2 is set equal to NN12. Also, a search is made for the integer k that will determine the smallest number TABLE (k) that equals or exceeds H(K,KR). If k = NN12 + 1 then I3 is set equal to NN12 + 2. If k is in [NN12 + 2, NN13] then I3 is set equal to k. If no k can be found in [NN12 + 2, NN13] then I3 is set equal to NN13. A final search is made for the integer m that will determine the smallest number TABLE (m) that equals or exceeds W(M,MR). If m = NN13 + 1 then I4 is set equal to NN13 + 2. If m is in [NN13 + 2, NN14] then I4 is set equal to m. If no m can be in [NN13 + 2, NN14] then I4 is set equal to NN14.

The next step is to identify the integers required for the final calculations.

With

NP12 = NTAB1 · NTAB2
NP13 = NP12 · NTAB3

these are:

N2222= NN14 +(I4 - NN13 - 1) · NP13 + (I3 - NN12 - 1) · NP12 + (I2 - NTAB1 - 1) · NTAB1 + I1
N1222 = N22 - 1
N2122 = N222 - NTAB1
N1122 = N2122 - 1
N2212 = N2222 - NP12

```
N1212 = N2212 - 1
N2112 = N2212 - NTAB1
N1112 = N2112 - 1
N2221 = N222 - NP13
N1221 = N2221 - 1
N2121 = N2221 - NTAB1
N1121 = N2121 - 1
N2211 = N2221 - NP12
N1211 = N2211 - 1
N2111 = N2211 - NTAB1
N1111 = N2111 - 1
```

Therefore, if

$$X1RAT = \frac{VI(I,IR) - TABLE\ (I1-1)}{TABLE\ (I1) - TABLE\ (I1-1)}$$

$$X2RAT = \frac{NZ(J,JR) - TABLE\ (I2-1)}{TABLE\ (I2) - TABLE\ (I2-1)}$$

$$X3RAT = \frac{H(K,KR) - TABLE\ (I3-1)}{TABLE\ (I3) - TABLE\ (I3-1)}$$

$$X4RAT = \frac{W(M,MR) - TABLE\ (I4-1)}{TABLE\ (I4) - TABLE\ (I4-1)}$$

then

```
AMP111 = TABLE(N1111) + X1RAT(TABLE(N2111) - TABLE(N1111))
AMP211 = TABLE(N1211) + X1RAT(TABLE(N2211) - TABLE(N1211))
AMP121 = TABLE(N1121) + X1RAT(TABLE(N2121) - TABLE(N1121))
AMP221 = TABLE(N1221) + X1RAT(TABLE(N2221) - TABLE(N1221))
AMP112 = TABLE(N1112) + X1RAT(TABLE(N2112) - TABLE(N1112))
AMP212 = TABLE(N1212) + X1RAT(TABLE(N2212) - TABLE(N1212))
AMP122 = TABLE(N1122) + X1RAT(TABLE(N2122) - TABLE(N1122))
AMP222 = TABLE(N1222) + X1RAT(TABLE(N2222) - TABLE(N1222)),

AMP11 = AMP111 + X2RAT(AMP211 - AMP111)
AMP12 = AMP112 + X2RAT(AMP212 - AMP112)
AMP22 = AMP122 + X2RAT(AMP222 - AMP122),

AMP1 = AMP11 + X3RAT(AMP21 - AMP11)
AMP2 = AMP12 + X3RAT(AMP22 - AMP12),
```

$$\xi^a\ (K,J,K,M,IR,JR,KR,MR) = (AMP1 + X4RAT(AMP2 - AMP1)) \cdot FACTØR$$

It is seen that the sixteen points on the Ψ^a surface are reduced to eight points on the Ξ^a surface by an interpolation on the indicated airspeed. The eight points are reduced to four points on the Ξ^a surface by an interpolation on the normal load factor. Next, the

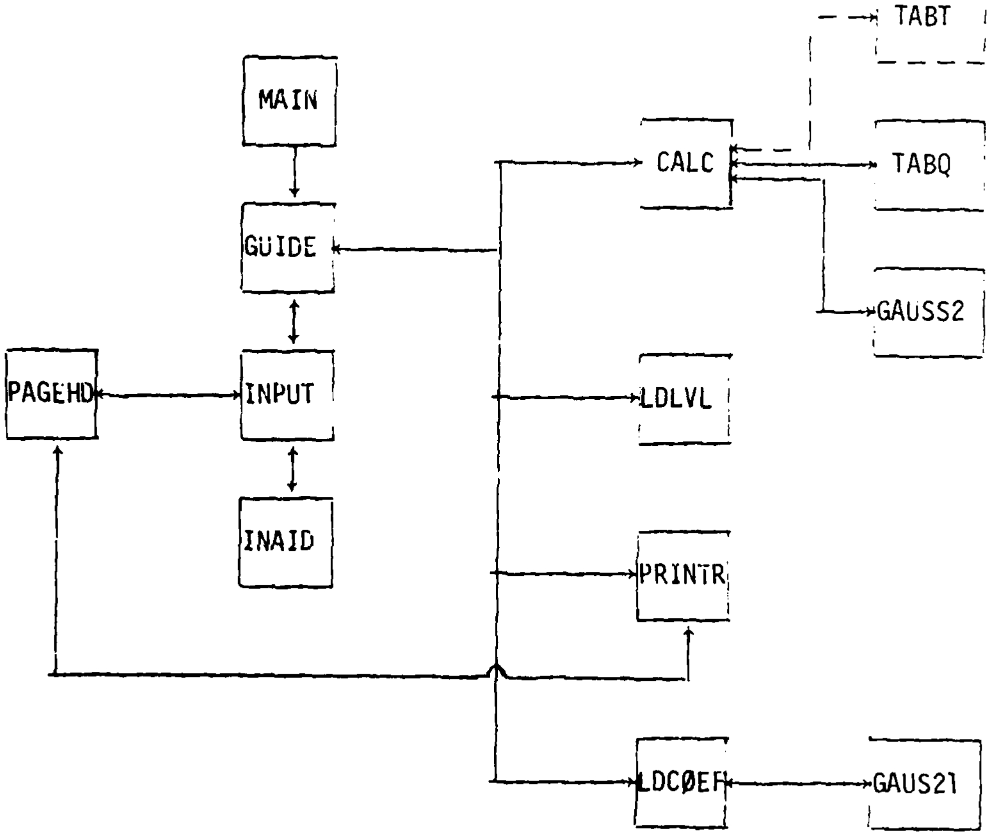
four points are reduced to two points on the ε^a surface by an interpolation on the altitude, and finally these two points are reduced to the desired stress by an interpolation on the weight.

Note that the number FACTØR is used to scale the calculation made in the table look up routine.

3 COMPUTER FLOW DIAGRAM AND PROGRAM

The computer routine was coded in FORTRAN Extended Language with the main program and subroutines arranged as follows:

SPECA Program (See Appendix A)



MAIN - Main Program - Sets NZERØ and NPSCT to zero and transfers program control to GUIDE

GUIDE - Subroutine - Initially zeros input and output numbers and after first case zeros output numbers before the calculations are performed. GUIDE, the main controlling subroutine, transfers control to INPUT, CALC, LDLVL, PRINTR, and LDCØEF in turn.

INPUT - Subroutine - Reads in all input data including the VGH histogram and the stress table. There are two formats for reading in floating point numbers and three formats for reading in fixed point numbers. The details of the data input are discussed later in this section.

INAID - Subroutine - Called by INPUT and has the purpose of writing out certain input data.

(1) NRVI, NRNZ, NRH, NRW
(2) FACTØR
(3) PSIL
(4) AREAN
(5) PS
(6) Stress table
(7) VGH histogram table
(8) FVI, FNZ, FH, FW

Also, INAID sets NZERO=1 for control of data handling in GUIDE

PAGEHD - Subroutine - Writes out page heading including run identification, date and page number

CALC - Subroutine - Computes PPSI and PDPSI

LDLVL - Subroutine - Computes PSIL and FRAC

LDCØEF - Subroutine - Computer ALPHA

TABQ - Subroutine - Called from CALC to perform the interpolation discussed in Section IV, B, that computes the stress corresponding to a given indicated airspeed, normal load factor, altitude, and weight.

TABT - Subroutine - called from CALC as an alternate to TABQ for the interpolation to compute the stress corresponding to a given indicated airspeed, equivalent normal load factor, and altitude.

GAUSS2 - Subroutine - Called from CALC to solve the simultaneous equations that are required to pass second order equations through the points of PFSI so that the differentiation for PDPSI can be performed. The subroutine uses the Gauss-Jordan method for solving the sets of simultaneous equations.

GAUS21 - Subroutine - Called from LDCØEF and is used to solve the set of equations PLD(I) = PS(K,J) * ALPHA(J). This subroutine is identical to GAUSS2 except for a DIMENSIØN statement change.

PRINTR - Subroutine - Called from GUIDE to write out computed output data. In particular, PRINTR prints

(1) PPSI
(2) EXCEED
(3) HØURS
(4) PDPSI
(5) PSILL, FRAC

4 EQUIVALENCE TABLES

The technique that has been used in coding this routine is to place all input and output numbers in blank common. All input and output floating point numbers are called parameters and are contained in P (dimensioned 10,000). All input and output fixed point numbers are called integers and are contained in NTEGER (dimensioned 100). To make the program more easily interpreted, EQUIVALENCE statements are used to provide the P and NTEGER numbers with more recognizable names. The SPECA program parameter and integer tables are given below.

PARAMETER EQUIVALENCE TABLE

P	Dimension	Term	P	Dimension	Term
1	(1)	FMN,FVI	1201	(100)	APDPSI(1)
2	(1)	FNZ	1300		APDPSI(100)
3	(1)	FH	1301	(100)	PSIL(1)
4	(1)	FW	1400		PSIL(100)
5	(1)	FACTØR	1401	(100)	FRAC(1)
6	(1)	HØURS	1500		FRAC(100)
.			1501	(100,25)	PLDS(1,1)
.			4000		PLDS(100,25)
.			4001	(25)	ALPHA(1)
.			4025		ALPHA(25)

P	Dimension	Term	P	Dimension	Term
100	(1)	NT	.		
101	(100)	PSIL(1)	.		
200		PSIL(100)	.		
201	(100)	AREAN(1)	5001	(25)	VII(1)
300		AREAN(100)	5025		VII(25)
301	(25,25)	PS(1,1)	5026	(25)	NZI(1)
925		PS(25,25)	5050		NZI(25)
.			5051	(25)	HI(1)
.			5075		HI(25)
.			5076	(25)	WI(1)
1001	(100)	PPSI(1)	5100		WI(25)
1100		PPSI(100)	.		
1101	(100)	PDPSI(1)	.		
1200		PDPSI(100)	6001	(100)	EXCEED(1)
			6100		EXCEED(100)

INTEGER EQUIVALENCE TABLE

NTEGER	Dimension	Term	NTEGER	Dimension	Term
1	(1)	IDENT	.		
2	.	NPF1	.		
3	.	NPF2	.		
4	.	NPF3	56	(2)	NTB41(1)
5		NPF4	57		NTB41(2)
6		NTI4	58	(2)	NTB42(1)
7		NTW4	59		NTB42(2)
8		MONTH	60	(2)	NTB42(1)
9		DAY	61		NTB43(2)
10		YEAR	62	(2)	NTB44(1)
11		NPSIL	63		NTB44(2)
12		NPSILL	64	(1)	NTB21
13		NPS	65	(1)	NTB22
14		NMORE			
15		NRMN			
16		NRNZ			
17		NRH			
18		NRW			
19					
20					
21		NTB			
.					
.					
.					
49		NPAGE			

5 INPUT DATA

All of the input data described below is read into the program by means of the subroutine INPUT. INPUT is a general purpose subroutine for reading data from cards. For this program, the full capabilities of INPUT are not required and consequently there will be some zeros in the input that serve to bypass certain options.

The following deck arrangement is recommended:

14I5 Format

IDENT	NPF1	0	0	0	NTI4	NTW4	MONTH	DAY	YEAR	NPSIL	NPSILL	NPS	21

7I5 Format

NRVI	NRNZ	NRH	NRW	0	0	NIB

72H Format

Run Description

72H Format

Run Description

3I5

1	6	1

6E10.3 Format

FVI	FNZ	FH	FW	FACTØR	HØURS

3I5 Format

101	100 + NPSIL	1

6E10.3 Format

PSIL(1) - PSIL(NPSIL)

3I5 Format

201	200 + NPSILL	1

6E10.3 Format

AREAN(1) - AREAN(NPSILL)

If NPS > 1 go to (a)

If NPS = 0 go to (b)

(a) 3I5 Format

301	300+ NPS	1

6E10.3 Format

PS(1,1) - (PS(NPS,1)

3I5 Format

326	325 + NPS	1

6E10.3 Format

PS(1,2) - PS(NPS,2)

3I5 Format

351	350 + NPS	1

6E10.3 Format

PS(1,3) - PS(NPS,3)

.

.

.

3I5 Format

301 + 25(NPS -1)	300 + (NPS-1) ·25+NPS	1

6E10.3 Format

PS(1,NPS) - PS(NPS,NPS)

(b) If NTI4 > 0 go to (c) to read NTI4 table(s). For the first run in a computer input the stress table and the VGH histogram table must be read. Subsequent runs may require no new tables (NTI4 = 0), one new table (NTI4 = 1), or two new tables (NTI4 = 2).

If NTI4 = 0 go to (g)

(c) 5I10 Format

1	NTAB1	NTAB2	NTAB3	NTAB4

(Stress table control cards)

6E10.3 Format

TABLE(1) - TABLE(NTAB1) (indicated airspeeds for the stress table)

6E10.3 Format

TABLE(NTAB1+1) - TABLE(NN12) (normal load factors for the stress table)

6E10.3 Format

TABLE(NN12+1) - TABLE(NN13) (altitudes for the stress table)

If NTB = 1 go to (d)

If NTB = 2 go to (e)

(d) 6E10.3 Format

TABLE(NN13+1) - TABLE(NN14) (weights for the stress table)

6E10.3 Format

TABLE(NN14+1) - TABLE(NF) (stress amplitudes for the stress table) (see Section 3.2 for ordering of these entries)

go to (f)

(e) E10.3 Format

WTTB3 (ref. weight)

6E10.3 Format

TABLE(NN13+1) - TABLE(NF) (stress amplitudes for the stress table) (see Section 3.2 for ordering of these entries)

(f) 5I10 Format

2	NT421	NT422	NT423	NT424

(VGH histogram control cards)

6E10.3 Format

VII(1) - VII(NT421)
(indicated airspeeds for VGH histogram table)

NZI(1) - NZI(NT422)
(normal load factor for VGH histogram table)

HI(1) - HI(NT423)
(altitudes for VGH histogram table)

WI(1) - WI(NT424)
(weights for VGH histogram table)

γ^a(VII(1),NZI(1),HI(1),WI(1)) -
γ^a(VII(NT421).NZI(NT422),HI(NT423,WI(NT424))
(load occurrences in VGH histogram table)
(see discussion below for ordering of these entries)

(g) END ØF FILE

The first card contains 14 fixed point (integer) numbers arranged in 15 fields. These 14 entries in order on this card are

(1) IDENT - run number
(2) NPF1 = 3 if $N_p = 1$

$= 3 + N_p$ if $N_p > 1$

(3) 0
(4) 0
(5) 0
(6) NT14 - the number of quadruple tables to be read (for this count the stress table and the VGH histogram table are each considered quadruple tables.)

(7) NIW4 = 1 for print of quadruple tables
= 0 otherwise

(8) MØNTH - month in date for page heading
(9) DAY - day in date for page heading
(10) YEAR - year in date for page heading
(11) NPSIL = N_{Γ_L}
(12) NPSILL = M
(13) NPS - The number of control points if $N_p > 1$. NPS = 0 if $N_p = 1$
(14) 21

The second card contains seven fixed point numbers arranged in I5 fields. In order these entries are

(1) NRVI = $N^R_{v_i}$
(2) NRNZ = $N^R_{n_z}$
(3) NRH = N^R_h
(4) NRW = N^R_w
(5) 0
(6) 0
(7) NTB = 1 if the load occurrences in the VGH histogram depend on indicated airspeed, normal load factor, altitude, and weight.
NTB = 2 if the load occurrences in the VGH histogram depend on indicated airspeed, equivalent normal load factor, and altitude

The third and fourth cards contain a 72H field each for the purpose of run description, etc.

The fifth card contains 1, 6, and 1 in I5 fields

The sixth card contains six floating point numbers arranged in E10.3 fields. These six numbers are placed in the following order:

(1) FVI = $v_i(N_{v_i}+1)$

(2) FNZ = $n_z(N_{n_z}+1)$

(3) FH = $h(N_h+1)$

(4) FW = $w(N_w+1)$

(5) FACTØR - stress scaling factor

(6) HØURS - number of hours of data in the VGH histogram

The seventh card contains the three fixed point numbers 101, 100 + NPSIL, 1 in order in I5 fields. NPSIL must not exceed 100.

The next card(s) contain(s) the numbers PSIL(1) through PSIL(NPSIL) in E10.3 fields, six numbers per card.

The next entry contains the fixed point numbers 201, 200 + NPSILL, 1 in order in I5 fields. NPSILL must not exceed 100.

Following this card the floating point numbers AREAN(1) through AREAN(NPSIL), arranged in E10.3 fields, six numbers per card, are entered.

If NPS = 0 then the PS matrix is omitted from the input deck.

If NPS ≠ 1 then the PS matrix is placed next in the input deck. PS is dimensioned (25,25) and is equivalenced to P such that P(301) = PS(1,1). Therefore, it follows that P(300+NPS) = PS(NPS,1), P(326) = PS(1,2), and P(301+25(NPS-1)) = PS(1,NPS). Consequently the NPS blocks of data are read in as follows:

First block -

> The first card contains the fixed point numbers 301, 300+NPS, 1 arranged in I5 fields.
>
> The next entries are the floating point numbers PS(1,1) through PS(NPS,1) in E10.3 fields, six numbers per card.

Second block -

> The first card contains the fixed point numbers 326, 325+NPS, 1 arranged in I5 fields.

The next entries are the floating point numbers PS(1,2) through PS(NPS,2) in E10.3 fields, six numbers per card.

.

.

.

NPSth block -

The first card contains the fixed point numbers 301+ 25(NPS-1), 300+(NPS-1)(25) + NPS arranged in I5 fields.

The next entries are the floating point numbers PS(1,NPS) through PS(NPS,NPS) in E10.3 fields, six numbers per card.

The remaining entries are the stress table and the VGH histogram table. These entries are prepared as follows:

If I = 1 then the entry is the stress table where there are NP = NTAB1 · NTAB2 · NTAB3 · NTAB4 points defined by NTAB1 indicated airspeeds, NTAB2 normal load factors, NTAB3 altitudes, NTAB4 weights. These points are entered as ordinates of the simple graph TABLE which was defined in paragraph 2 of this section.
The first card for the stress table contains five (5) fixed point numbers in I5 fields in the order

(1) 1
(2) NTAB1
(3) NTAB2
(4) NTAB3
(5) NTAB4

The next card(s) contain(s) the indicated airspeeds (floating point numbers) TABLE(1) through TABLE(NTAB1) arranged in E10.6 fields, six numbers per card.

The next entries are the normal load factors TABLE(NTAB1 +1, NN12) (see paragraph 2 for definition of arguments) arranged in E10.3 fields six numbers per card.

Next, the card(s) that contain the altitudes TABLE(NN12+1) through TABLE(NN13) arranged in E10.3 fields, six numbers per card are entered in order.

The next entries depend on the number NTB.

If NTB = 1 the card(s) that contain(s) the weights TABLE(NN13+1) through TABLE(NN14) arranged in E10.3 fields, are entered with six numbers per card.

The next card(s) contain(s) the stresses TABLE(NN14+1) through TABLE(NF) arranged in E10.3 fields, six numbers per card. The ordering of the stresses in this entry is defined in paragraph 2 of this section.

If NTB = 2 a card is entered that contains the reference weight WTTB3 in an E10.3 field.

The next card(s) contain(s) the stresses TABLE(NN13+1) through TABLE(NF) arranged in E10.3 fields, six numbers per card. The number NF must not exceed 2000. The ordering of the stresses in this entry is defined in paragraph 2 of this section. (Note that NTAB4 = 1 for this case.)

This completes the stress table

If I = 2 then the entry is the VGH histogram table where there are NP24 = NT421 · NT422 · NT423 · NT424 regions defined by NT421 indicated airspeed intervals, NT422 normal load factor intervals, NT423 altitude intervals, and NT424 weight intervals.

The first card for the VGH histogram table contains five fixed point numbers in I5 fields in the order

(1) 2
(2) NT421
(3) NT422
(4) NT423
(5) NT424

Following this card are the card(s) with the indicated airspeeds (floating point numbers) VII(1) through VII(NT421) arranged in E10.3 fields, six numbers per card.

The next card(s) contain the normal load factors NZI(1) through NZI(NT422) arranged in E10.3 fields, six numbers per card.

Next are the card(s) that contain the altitudes HI(1) through HI(NT423) arranged in E10.3 fields, six numbers per card.

The weight entries WI(1) through WI(NT424) arranged in E10.3 field, six numbers per card, are next.

The final card(s) in the VGH histogram deck are the load occurrences in regions defined by the indicated airspeeds, normal load factors, altitudes, and weights. If a is in [1,NP] then these entries are ψ^a(VII(1),NZI(1), HI(1), WI(1)) through ψ^a(VII(NT421), NZI(NT422), HI(NT423), WI(NT424)) arranged in E10.3 fields, six numbers per card. If i is in [1,NT421], j is in [1,NT422], k is in [1,NT423], and m is in [1,NT424] then the stress that corresponds to VII(i), NZI(j), HI(k), WI(m) is the((m-1) · NT421 · NT422 · NT423 + (k-1) · NT421 · NT422 + (j-1) · NT421+i)th entry on these cards. The number NT421 + NT422 + NT423 + NT424 + NT421 · NT422 · NT423 · NT424 must not exceed 2000.

6 SAMPLE PROBLEM

A sample run is presented for the purpose of acquainting the user with the input data cards and the output. The data used does not represent any particular aircraft or usage. It is assumed that two control points are sufficient in this case to define the full scale aircraft fatigue spectrum. The input cards are as follows:

```
 100    5    0    0    0    2    1    8   30 1973   23   12  2   21
   2    2    2    2    0    0    1
        CHECK OUT RUN FOR SPECA PROGRAM
        V G H DATA IN TABLE   CONTROL POINT NUMBER 1  (REVISION 2)
   1    6    1
650.0      7.0          40000.0    36000.0    1.0         500.0
  101  123    1
20000.0    22000.0      24000.0    26000.0    28000.0     30000.0
32000.0    34000.0      36000.0    38000.0    40000.0     42000.0
44000.0    46000.0      48000.0    50000.0    52000.0     54000.0
56000.0    58000.0      60000.0    62000.0    64000.0
  201  212    1
0.05       0.10         0.20       0.25       0.30        0.40
0.50       0.60         0.70       0.80       0.90        0.95
  301  302    1
20000.0    35000.0
```

```
  326   327      1
25000.0    30000.0
           1          3          3          3          3
300.0      500.0      600.0
3.0        6.0        8.0
5000.0     20000.0    35000.0
25000.0    30000.0    35000.0
20000.0    22000.0    25000.0    42000.0    43000.0    46000.0
55000.0    57000.0    58000.0    17000.0    18000.0    20000.0
32000.0    34000.0    35000.0    51000.0    53000.0    54000.0
15000.0    17000.0    18000.0    26000.0    28000.0    29000.0
41000.0    42000.0    44000.0    24000.0    26000.0    29000.0
46000.0    47000.0    50000.0    59000.0    61000.0    62000.0
21000.0    22000.0    24000.0    36000.0    38000.0    39000.0
55000.0    57000.0    58000.0    19000.0    21000.0    22000.0
30000.0    32000.0    33000.0    45000.0    46000.0    48000.0
27000.0    29000.0    32000.0    49000.0    50000.0    53000.0
62000.0    64000.0    65000.0    24000.0    25000.0    27000.0
39000.0    41000.0    42000.0    58000.0    60000.0    61000.0
22000.0    24000.0    25000.0    33000.0    35000.0    36000.0
48000.0    49000.0    51000.0
           2          3          3          3          3
350.0      450.0      550.0
4.0        5.0   6.0
10000.0    20000.0    30000.0
30000.0    32000.0    34000.0
500.0      1000.0     600.0      1000.0     1100.0     600.0
700.0      770.0      7700.0     100.0      4000.0     600.0
1000.0     100.0      1000.0     700.0      2000.0     600.0
6000.0     1000.0     4000.0     600.0      6000.0     1000.0
700.0      1000.0     6000.0     3000.0     600.0      700.0
1000.0     2000.0     500.0      4000.0     700.0      1000.0
500.0      4000.0     6000.0     700.0      7000.0     7700.0
4000.0     2000.0     700.0      500.0      3000.0     500.0
1000.0     600.0      3000.0     1000.0     500.0      5000.0
700.0      4000.0     600.0      3000.0     4000.0     400.0
1000.0     100.0      500.0      5000.0     5500.0     4000.0
500.0      1000.0     700.0      500.0      5000.0     3000.0
600.0      6000.0     3000.0     2000.0     4000.0     3000.0
1000.0     2000.0     200.0
  100      0     0     0     0     1     1     8    30 1973    23    12   2    21
    2      2     2     2     0     0     1
           CHECK OUT FOR SPECA PROGRAM
           V G H DATA IN TABLE    CONTROL POINT NUMBER 2
           1          3          3          3          3
300.0      500.0      600.0
```

3.0	6.0	8.0			
5000.0	20000.0	35000.0			
25000.0	30000.0	35000.0			
10000.0	20000.0	24000.0	36000.0	39000.0	40000.0
45000.0	50000.0	53000.0	17000.0	18000.0	20000.0
25000.0	27000.0	30000.0	51000.0	53000.0	54000.0
15000.0	17000.0	18000.0	26000.0	28000.0	29000.0
32000.0	34000.0	36000.0	25000.0	26000.0	27000.0
42000.0	43000.0	44000.0	55000.0	56000.0	57000.0
21000.0	22000.0	24000.0	36000.0	38000.0	39000.0
55000.0	57000.0	58000.0	19000.0	21000.0	22000.0
30000.0	32000.0	33000.0	45000.0	46000.0	48000.0
27000.0	29000.0	32000.0	49000.0	50000.0	53000.0
62000.0	64000.0	65000.0	24000.0	25000.0	27000.0
39000.0	41000.0	42000.0	58000.0	60000.0	61000.0
22000.0	24000.0	25000.0	33000.0	35000.0	36000.0
48000.0	49000.0	51000.0			

Based on this input the following output listing was obtained.

RUN NO 100 DATE 8/30/1973 PAGE NO 1

CHECK OUT RUN FOR SPECA PROGRAM

V G H DATA IN TABLE CONTROL POINT NUMBER 1 (REVISION 2)

HISTOGRAM SUBDIVISIONS

NRVT = 2

NRNZ = 2

NRH = 2

NRW = 2

LOAD MAGNIFICATION FACTOR = 1.0000

INTERNAL LOAD LEVELS FOR INTEGRATION OF JOINT DENSITY FUNCTION

1	2.00000E+04	2	2.20000E+04	3	2.40000E+04	4	2.60000E+04
5	2.80000E+04	6	3.00000E+04	7	3.20000E+04	8	3.40000E+04
9	3.60000E+04	10	3.80000E+04	11	4.00000E+04	12	4.20000E+04
13	4.40000E+04	14	4.60000E+04	15	4.80000E+04	16	5.00000E+04
17	5.20000E+04	18	5.40000E+04	19	5.60000E+04	20	5.80000E+04
21	6.00000E+04	22	6.20000E+04	23	6.40000E+04	24	0.

CUMULATIVE AREAS OF LOAD PROBABILITY DENSITY FUNCTION
FOR SPECTRUM LOAD LEVELS

1	5.00000E-02	2	1.00000E-01	3	2.00000E-01	4	2.50000E-01
5	3.00000E-01	6	4.00000E-01	7	5.00000E-01	8	6.00000E-01
9	7.00000E-01	10	8.00000E-01	11	9.00000E-01	12	9.50000E-01

RUN NO 100 DATE 8/30/1973 PAGE NO 2

QUADRUPLE TABLE NO. 1

PSI VS VI, NZ, H, W

VI

300.0 500.0 600.0

NZ

3.0000 6.0000 8.0000

H

5000. 20000. 35000.

W

25000. 30000. 35000.

PSI

20000.	22000.	25000.	42000.	43000.	46000.	55000.	57000.	58000.	17000.	18000.	20000.
32000.	34000.	35000.	51000.	53000.	54000.	15000.	17000.	18000.	26000.	28000.	20000.
41000.	42000.	44000.	24000.	26000.	29000.	46000.	47000.	50000.	53000.	61000.	62000.
21000.	22000.	24000.	36000.	38000.	39000.	55000.	57000.	58000.	19000.	21000.	22000.
30000.	32000.	33000.	45000.	46000.	48000.	27000.	29000.	32000.	49000.	50000.	51000.
62000.	64000.	65000.	24000.	25000.	27000.	39000.	41000.	42000.	59000.	60000.	61000.
22000.	24000.	25000.	33000.	35000.	36000.	48000.	49000.	51000.			

RUN NO 100 DATE 8/30/1973 PAGE NO 3

QUADRUPLE TABLE NO. 2
HISTJ VS VI, NZ, H, W
VI
350.0 450.0 550.0
NZ
4.0000 5.0000 6.0000
H
10000. 20000. 3000 .
W
30000. 32000. 34000.
HISTJ

500.	1000.	600.	1000.	1100.	600.	700.	770.	7700.	100.	4000.	600.
1000.	100.	2000.	700.	2000.	600.	6000.	1000.	4000.	600.	4000.	1000.
700.	1000.	4000.	3000.	600.	700.	1000.	2000.	500.	4000.	700.	1000.
500.	4000.	6000.	700.	7000.	7700.	4000.	2000.	700.	500.	3000.	500.
1000.	600.	3000.	1000.	500.	5000.	700.	4000.	600.	3000.	4000.	400.
1000.	100.	500.	5000.	5500.	4000.	500.	1000.	700.	500.	4000.	4000.
500.	6000.	3000.	2000.	4000.	3000.	1000.	2000.	200.			

LAST ABSCISSAS IN TABLE 2
FVI = .650000E+03
FNZ = .700000E+01
FH = .400000E+05
FW = .360000E+05

RUN NO 100 DATE 8/30/1973 PAGE NO 4

INTERNAL LOAD CUMULATIVE PROBABILITY FUNCTION

LOAD	CUM PROB	LOAD	CUM PROB	LOAD	CUM PROB
2.000000E+04	1.000000E+00	2.200000E+04	1.000000E+00	2.400000E+04	1.000000E+00
2.600000E+04	9.810190E-01	2.800000E+04	9.306560E-01	3.000000E+04	8.316293E-01
3.200000E+04	6.960719E-01	3.400000E+04	5.440577E-01	3.600000E+04	4.227599E-01
3.800000E+04	3.221785E-01	4.000000E+04	2.443382E-01	4.200000E+04	1.738843E-01
4.400000E+04	1.181307E-01	4.600000E+04	7.876584E-02	4.800000E+04	3.980130E-02
5.000000E+04	1.782409E-02	5.200000E+04	1.843871E-03	5.400000E+04	1.997717E-04
5.600000E+04	0.	5.800000E+04	0.	6.000000E+04	0.
6.200000E+04	0.	6.400000E+04	0.	0.	0.

RUN NO 100 DATE 8/30/1973 PAGE NO 5

CUMULATIVE NUMBER OF EXCEEDANCES PER 1000 HRS

LOAD	EXCEEDANCES	LOAD	EXCEEDANCES	LOAD	EXCEEDANCES
2.000000E+04	3.457400E+05	2.200000E+04	3.457400E+05	2.400000E+04	3.457400E+05
2.600000E+04	3.391775E+05	2.800000E+04	3.217650E+05	3.000000E+04	2.875275E+05
3.200000E+04	2.372025E+05	3.400000E+04	1.801025E+05	3.600000E+04	1.461650E+05
3.800000E+04	1.113900E+05	4.000000E+04	8.447750E+04	4.200000E+04	6.011875E+04
4.400000E+04	4.084250E+04	4.600000E+04	2.723250E+04	4.800000E+04	1.348500E+04
5.000000E+04	6.162500E+03	5.200000E+04	6.375000E+02	5.400000E+04	6.250000E+01
5.600000E+04	0.	5.800000E+04	0.	6.000000E+04	0.
6.200000E+04	0.	6.400000E+04	0.	0.	0.

BASED ON 500.00 HOURS

RUN NO 100 DATE 8/30/1973 PAGE NO 6

INTERNAL LOAD PROBABILITY DENSITY FUNCTION

LOAD	PROB DEN	LOAD	PROB DEN	LOAD	PROB DEN
2.000000E+04	-3.957328E-19	2.200000E+04	1.562652E-19	2.400000E+04	4.745257E-06
2.600000E+04	1.733600E-05	2.800000E+04	3.734743E-05	3.000000E+04	6.114602E-05
3.200000E+04	7.189790E-05	3.400000E+04	6.542801E-05	3.600000E+04	5.546979E-05
3.800000E+04	4.460541E-05	4.000000E+04	3.707356E-05	4.200000E+04	3.155189E-05
4.400000E+04	2.[illegible]E-05	4.600000E+04	1.978184E-05	4.800000E+04	1.523544E-05
5.000000E+04	9.280857E-06	5.200000E+04	4.410829E-06	5.400000E+04	4.609678E-07
5.600000E+04	4.[illegible]E-08	5.800000E+04	0.	6.000000E+04	0.
6.200000E+04	0.	6.400000E+04	0.	0.	0.

RUN NO 100 DATE 8/30/1973 PAGE NO 7

CYCLIC LOADING FRACTIONS

LOAD	FRACTION	LOAD	FRACTION	LOAD	FRACTION
2.74[illegible]E+04	7.500000E-02	2.872792E+04	7.500000E-02	3.043048E+04	7.500000E-02
3.111[illegible]E+04	5.000000E-02	3.180650E+04	7.500000E-02	3.317683E+04	1.000000E-01
3.468790E+04	1.000000E-01	3.641536E+04	1.000000E-01	3.855091E+04	1.000000E-01
4.120875E+04	1.000000E-01	4.492367E+04	7.500000E-02	4.734396E+04	7.500000E-02

TOTAL LOAD CYCL S = 172870.

```
RUN NO   100          DATE    8/30/1973          PAGE NO     8
CHECK OUT FOR SPECA PROGRAM
V G H DATA IN TABLE     CONTROL POINT NUMBER 2

HISTOGRAM SUBDIVISIONS
NRVI =      2
NRN2 =      2
NRH  =      2
NRW  =      2

LOAD MAGNIFICATION FACTOR =     1.0000

INTERNAL LOAD LEVELS FOR INTEGRATION OF JOINT DENSITY FUNCTION
   1    2.00000E+04      2   2.20000E+04      3   2.40000E+04      4   2.60000E+04
   5    2.80000E+04      6   3.00000E+04      7   3.20000E+04      8   3.40000E+04
   9    3.60000E+04     10   3.80000E+04     11   4.00000E+04     12   4.20000E+04
  13    4.40000E+04     14   4.60000E+04     15   4.80000E+04     16   5.00000E+04
  17    5.20000E+04     18   5.40000E+04     19   5.60000E+04     20   5.80000E+04
  21    6.00000E+04     22   6.20000E+04     23   6.40000E+04     24   0.

CUMULATIVE AREAS OF LOAD PROBABILITY DENSITY FUNCTION
FOR SPECTRUM LOAD LEVELS
   1    5.00000E-02      2   1.00000E-01      3   2.00000E-01      4   2.50000E-01
   5    3.00000E-01      6   4.00000E-01      7   5.00000E-01      8   6.00000E-01
   9    7.00000E-01     10   8.00000E-01     11   9.00000E-01     12   9.50000E-01
```

BALANCED LOAD CONDITION MATRIX

2.000000E+04	2.500000E+04
3.500000E+04	3.000000E+04

RUN NO 100 DATE 8/30/1973 PAGE NO 10

QUADRUPLE TABLE NO. 1
PST VS VI, N7, H, W

VI

300.0	500.0	600.0

N7

3.0000	6.0000	8.0000

H

5000.	20000.	35000.

W

25000.	30000.	35000.

PST

13000.	20000.	24000.	36000.	39000.	40000.	45000.	50000.	53000.	17000.	18000.	20000.
25000.	27000.	30000.	51000.	53000.	54000.	15000.	17000.	18000.	26000.	28000.	29000.
33000.	34000.	35000.	25000.	26000.	27000.	42000.	43000.	44000.	55000.	56000.	57000.
21000.	22000.	24000.	36000.	38000.	39000.	55000.	57000.	58000.	19000.	21000.	22000.
30000.	32000.	33000.	45000.	46000.	48000.	27000.	29000.	32000.	49000.	50000.	53000.
63000.	64000.	65000.	24000.	25000.	27000.	39000.	41000.	42000.	58000.	60000.	61000.
22000.	24000.	25000.	33000.	35000.	36000.	48000.	49000.	51000.			

RUN NO 100 DATE 8/30/1973 PAGE NO 11

QUADRUPLE TABLE NO. 2
HISTJ VS VI, NZ, H, W
VI
350.0 450.0 550.0
NZ
4.0000 5.0000 6.0000
H
10000. 20000. 30000.
W
30000. 33000. 34000.
HISTJ

500.	1000.	600.	1000.	1100.	600.	700.	770.	7700.	100.	4000.	600.
1000.	100.	1300.	700.	2000.	600.	6000.	1000.	4000.	600.	6000.	1000.
700.	1000.	5000.	3000.	600.	700.	1000.	2000.	500.	4000.	700.	1000.
500.	4000.	6000.	700.	7000.	7700.	4000.	2000.	700.	500.	3000.	500.
1000.	700.	3000.	1000.	500.	5000.	700.	4000.	600.	3000.	4000.	400.
1000.	100.	500.	5000.	5500.	4000.	500.	1000.	700.	500.	5000.	1000.
600.	6000.	3000.	2000.	4000.	3000.	1000.	2000.	200.			

LAST ABSCISSAS IN TABLE 2
FVI = .65000E+03
FNZ = .70000E+01
FH = .40000E+05
FW = .36000E+05

RUN NO 100 DATE 8/30/1973 PAGE NO 12

INTERNAL LOAD CUMULATIVE PROBABILITY FUNCTION

LOAD	CUM PROB	LOAD	CUM PROB	LOAD	CUM PROB
2.000000E+04	1.000000E+00	2.200000E+04	1.000000E+00	2.400000E+04	1.000000E+00
2.600000E+04	9.810190E-01	2.800000E+04	9.306560E-01	3.000000E+04	9.314485E-01
[illegible]	6.8[illegible]7E-01	3.400000E+04	5.413461E-01	3.600000E+04	4.203014E-01
[illegible]	3.2[illegible]E-01	4.000000E+04	2.393951E-01	4.200000E+04	1.681574E-01
4.4[illegible]E+04	1.084731E-01	4.600000E+04	6.496573E-02	4.800000E+04	2.782799E-02
5.0[illegible]E+04	4.71[illegible]E-03	5.200000E+04	7.592410E-04	5.400000E+04	1.807717E-04
5.6[illegible]E+04	0.	5.800000E+04	0.	6.000000E+04	0.
6.2[illegible]E+04	0.	6.400000E+04	0.	0.	0.

RUN NO 100 DATE 8/30/1973 PAGE NO 13

CUMULATIVE NUMBER OF EXCEEDANCES PER 1000 HRS

LOAD	EXCEEDANCES	LOAD	EXCEEDANCES	LOAD	EXCEEDANCES
2.000000E+04	3.457400E+05	2.200000E+04	3.457400E+05	2.400000E+04	3.457400E+05
2.600000E+04	3.391775E+05	2.800000E+04	3.217650E+05	3.000000E+04	2.874650E+05
3.200000E+04	2.363775E+05	3.400000E+04	1.871650E+05	3.600000E+04	1.453150E+05
3.800000E+04	1.106525E+05	4.000000E+04	8.276500E+04	4.200000E+04	5.813675E+04
4.400000E+04	3.750375E+04	4.600000E+04	2.246125E+04	4.800000E+04	9.621250E+03
5.000000E+04	1.637500E+03	5.200000E+04	2.625000E+02	5.400000E+04	6.250000E+01
5.600000E+04	0.	5.800000E+04	0.	6.000000E+04	0.
6.200000E+04	0.	6.400000E+04	0.	0.	0.

BASED ON 500.00 HOURS

RUN NO 100 DATE 8/30/1977 PAGE NO 14

INTERNAL LOAD PROBABILITY DENSITY FUNCTION

LOAD	PROB DEN	LOAD	PROB DEN	LOAD	PROB DEN
2.000000E+04	-3.957329E-19	2.200000E+04	6.562652E-19	2.400000E+04	4.845257E-06
2.600000E+04	1.733600E-05	2.800000E+04	3.739282E-05	3.000000E+04	6.174257E-05
3.200000E+04	7.252560E-05	3.400000E+04	6.584608E-05	3.600000E+04	5.532517E-05
3.800000E+04	4.522007E-05	4.000000E+04	3.797193E-05	4.200000E+04	3.272781E-05
4.400000E+04	2.579793E-05	4.600000E+04	2.016147E-05	4.800000E+04	1.505778E-05
5.000000E+04	6.767188E-06	5.200000E+04	1.138862E-06	5.400000E+04	1.898103E-07
5.600000E+04	4.519292E-08	5.800000E+04	0.	6.000000E+04	0.
6.200000E+04	0.	6.400000E+04	0.	0.	0.

RUN NO 100 DATE 8/30/1973 PAGE NO 15

CYCLIC LOADING FRACTIONS

LOAD	FRACTION	LOAD	FRACTION	LOAD	FRACTION
2.742954E+04	7.500000E-02	2.873156E+04	7.500000E-02	3.041958E+04	7.500000E-02
3.109333E+04	5.000000E-02	3.177553E+04	7.500000E-02	3.313918E+04	1.000000E-01
3.4[illegible]E+04	1.000000E-01	3.637520E+04	1.000000E-01	3.847583E+04	1.000000E-01
4.106355E+04	1.000000E-01	4.436757E+04	7.500000E-02	4.671888E+04	7.500000E-02

TOTAL LOAD CYCLES = 172870

```
COEFFICIENTS FOR FREQUENCY LEVEL NO.    1
2.693595E+00  -1.996876E+00

COEFFICIENTS FOR FREQUENCY LEVEL NO.    2
2.611960E+00  -2.089569E+00

COEFFICIENTS FOR FREQUENCY LEVEL NO.    3
2.765410E+00  -2.212331E+00

COEFFICIENTS FOR FREQUENCY LEVEL NO.    4
2.826665E+00  -2.261333E+00

COEFFICIENTS FOR FREQUENCY LEVEL NO.    5
2.888684E+00  -2.310947E+00

COEFFICIENTS FOR FREQUENCY LEVEL NO.    6
3.0126[illegible]E+00  -2.410127E+00

COEFFICIENTS FOR FREQUENCY LEVEL NO.    7
3.149601E+00  -2.519681E+00

COEFFICIENTS FOR FREQUENCY LEVEL NO.    8
3.306837E+00  -2.645467E+00

COEFFICIENTS FOR FREQUENCY LEVEL NO.    9
3.497803E+00  -2.798247E+00

COEFFICIENTS FOR FREQUENCY LEVEL NO.   10
3.733232E+00  -2.986585E+00

COEFFICIENTS FOR FREQUENCY LEVEL NO.   11
4.033415E+00  -3.276737E+00

COEFFICIENTS FOR FREQUENCY LEVEL NO.   12
4.247171E+00  -3.397737E+00

END-OF-FILE ENCOUNTERED, FILENAME -     INPUT
ERROR NUMBER   0065 DETECTED BY INPC=   AT ADDRESS 000160
CALLED FROM INPUT    AT  LINE 0061
CALLED FROM GUTPC    AT  LINE 0017
CALLED FROM SPECA    AT  LINE 0010
```

SECTION IV

EXAMPLE PROBLEM - F-4 STRESS SPECTRUM FOR POSITIVE LOAD FACTORS

The data base for this problem is four quarters of VGH data starting with the second quarter of 1972 and finishing with the first quarter of 1973. The VGH histogram intervals for these data are the following:

Indicated airspeed (knots)
150, 200, 250, 300, 350, 400, 450, 500, 550, 625, and 700

Normal load factor (equivalent)
1.4, 1.8, 2.2, 2.6, 3.0, 3.8, 4.6, 5.4, 6.6, 7.8, and 9.0

Altitude (feet)
0. 1000, 2000, 5000, 10,000, 15,000, 20,000, 30,000, 40,000, and 50,000

Weight (pounds)
37,500 (reference weight)

The stress table was set up with the following indicated airspeed, normal load factor, altitude, and weight combinations:

Indicated airspeed (knots)
175, 225, 275, 325, 375, 425, 475, 525, 575, and 625

Normal load factor
2.4, 2.8, 3.4, 4.2, 5.0, 6.0, 7.2, and 8.9

Altitude (feet)
500, 1500, 3500, 7500, 12500, 17500, 25000, and 35000

Weight (pounds)
37,500

The VGH histogram table was made up using all of the available data for the air-to-air and air-to-ground operations for the four quarters without distinguishing the various F-4 models except that only the unslatted configurations were considered. The numbers of hours of data in each category and their corresponding numbers of positive and negative load occurrences are shown in Table 1.

The number of stress exceedances per 1000 hours for load reference station (LRS) 180, defined in Figure 1 is shown in Figure 2 through Figure 7. Figure 2 through Figure 5 shows the variation from quarter to quarter of the VGH data. The stress exceedance graphs appear to show a small degree of scatter except for the SEA air-to-air first quarter where there was an overt change in the mission although it was still categorized as air-to-air. The four quarters of data are combined in Figures 6 and 7 to show the differences between the CONUS and SEA in the air-to-air operation and the air-to-ground operation.

SECTION V

CONCLUSIONS

The procedure described in this report can eliminate much of the uncertainty that can occur in the derivation of the maneuver load stress spectrum. For new aircraft an estimate must be made of the VGH histogram to obtain the spectrum. This estimate can be updated during Task V of ASIP to derive a better estimate for the operational life of the fleet. This procedure can be immediately applied to fleet tracking by computing the conditional probability of exceeding a stress level given the normal load factor.

The application to full scale aircraft testing makes use of the assumption that the stress is matched at a specified number of control points by a linear combination of the same number of balanced loading conditions. This technique is believed to be more accurate than the usual process of a damage match at the specified control points in that the troublesome damage calculation is eliminated. The stress spectra at points other than control points are presumed to be matched satisfactorily by using representative loading conditions. It is, of course, theoretically better to use all points of the sky that occur in the VGH histogram. This, however, may be impractical due to test equipment limitations.

The procedure as applied to the F-4 fleet indicates that in general the stress spectra do not show significant changes from quarter to quarter. Also, when an operational change is made the method will reflect that change. When CONUS and SEA data are compared there appears to be a reasonably good correlation between the spectra generated in training and the spectra generated in combat.

TABLE 1. F-4 VGH DATA SUMMARY

PERIOD	TYPE	HOURS	+ COUNTS	- COUNTS	TOTAL COUNTS
2Q 72	CONUS AA	196.87	13981	4541	18522
2Q 72	SEA AA	65.84	4047	662	4709
2Q 72	CONUS AG	251.70	30723	9432	40155
2Q 72	SEA AG	1248.94	93027	13258	106285
3Q 72	CONUS AA	290.22	17470	5259	22729
3Q 72	SEA AA	393.26	30842	6366	37208
3Q 72	CONUS AG	469.64	38968	9934	48902
3Q 72	SEA AG	802.74	66446	12485	78931
4Q 72	CONUS AA	184.92	9404	3138	12542
4Q 72	SEA AA	164.35	7862	1933	9795
4Q 72	CONUS AG	89.16	5959	1265	7224
4Q 72	SEA AA	502.09	28254	4819	33073
1Q 73	CONUS AA	123.18	7983	2231	10214
1Q 73	SEA AA	133.96	6100	1358	7458
1Q 73	CONUS AG	194.38	17828	4001	21829
1Q 73	SEA AG	933.87	42342	8229	50571

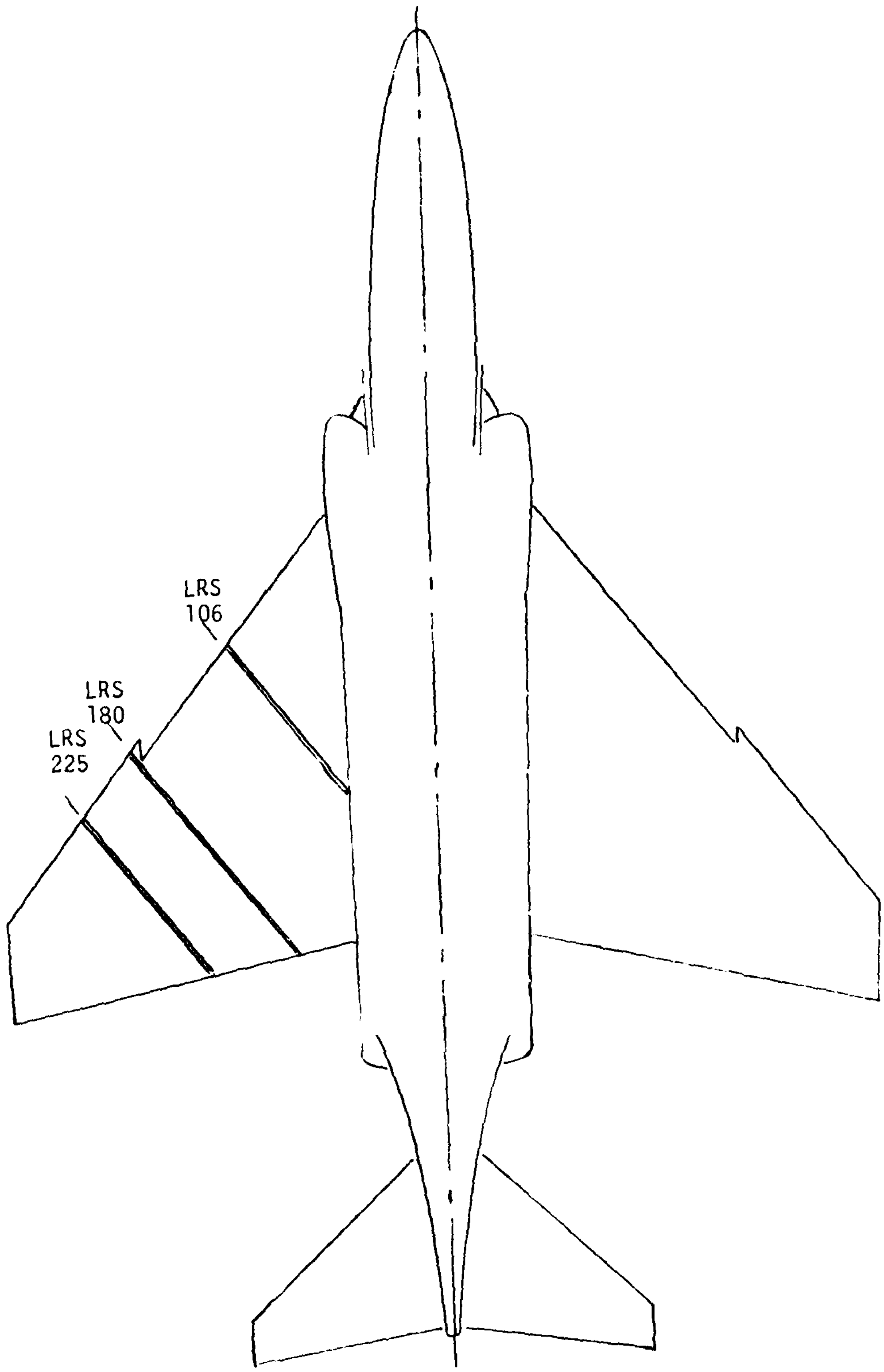


Figure 1. F-4 Wing Load Reference Station Locations

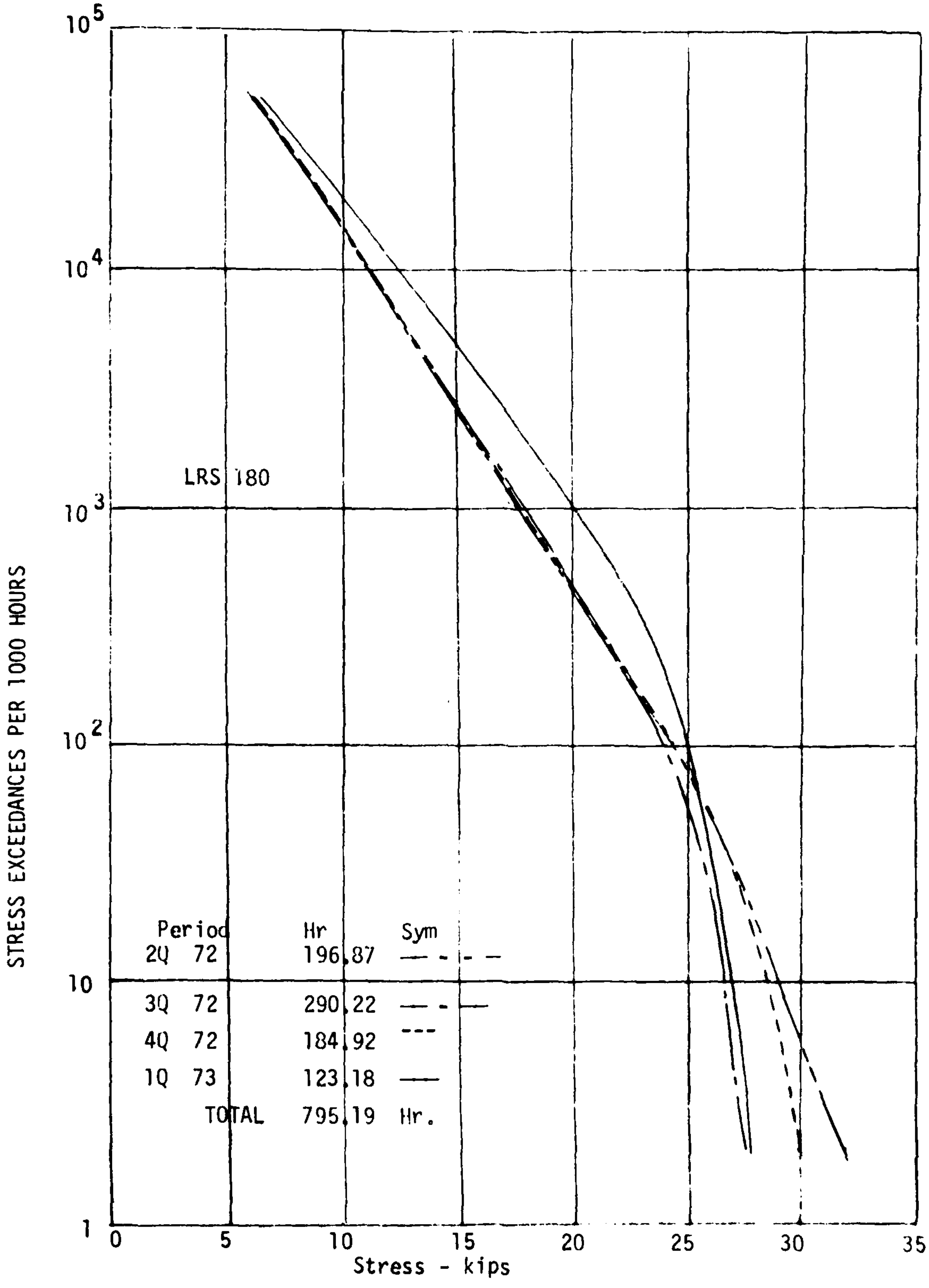


Figure 2. F-4 Spectra - CONUS Air-to-Air (All Models)

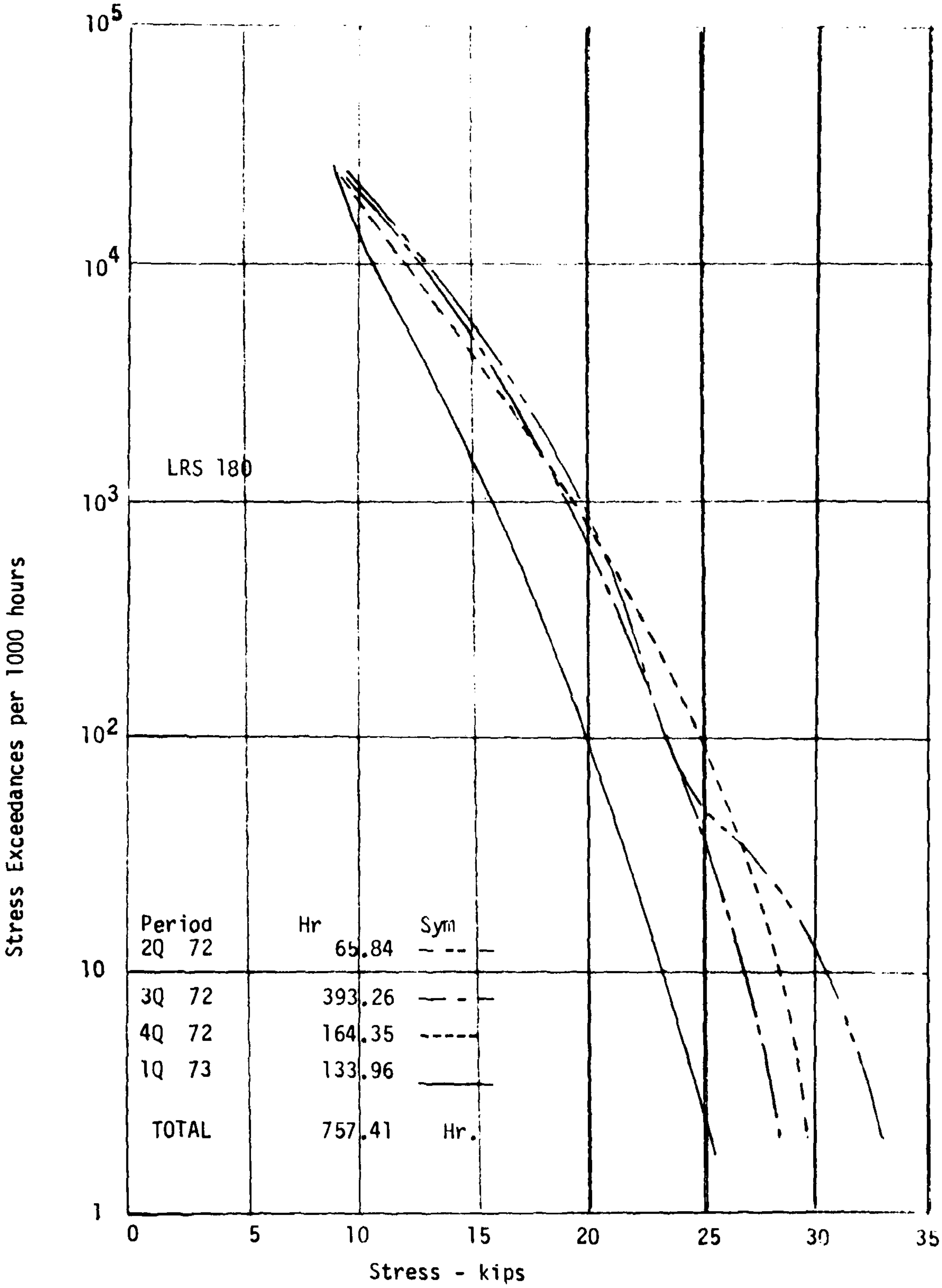


Figure 3. F-4 Spectra - SEA Air-to-Air (All Models)

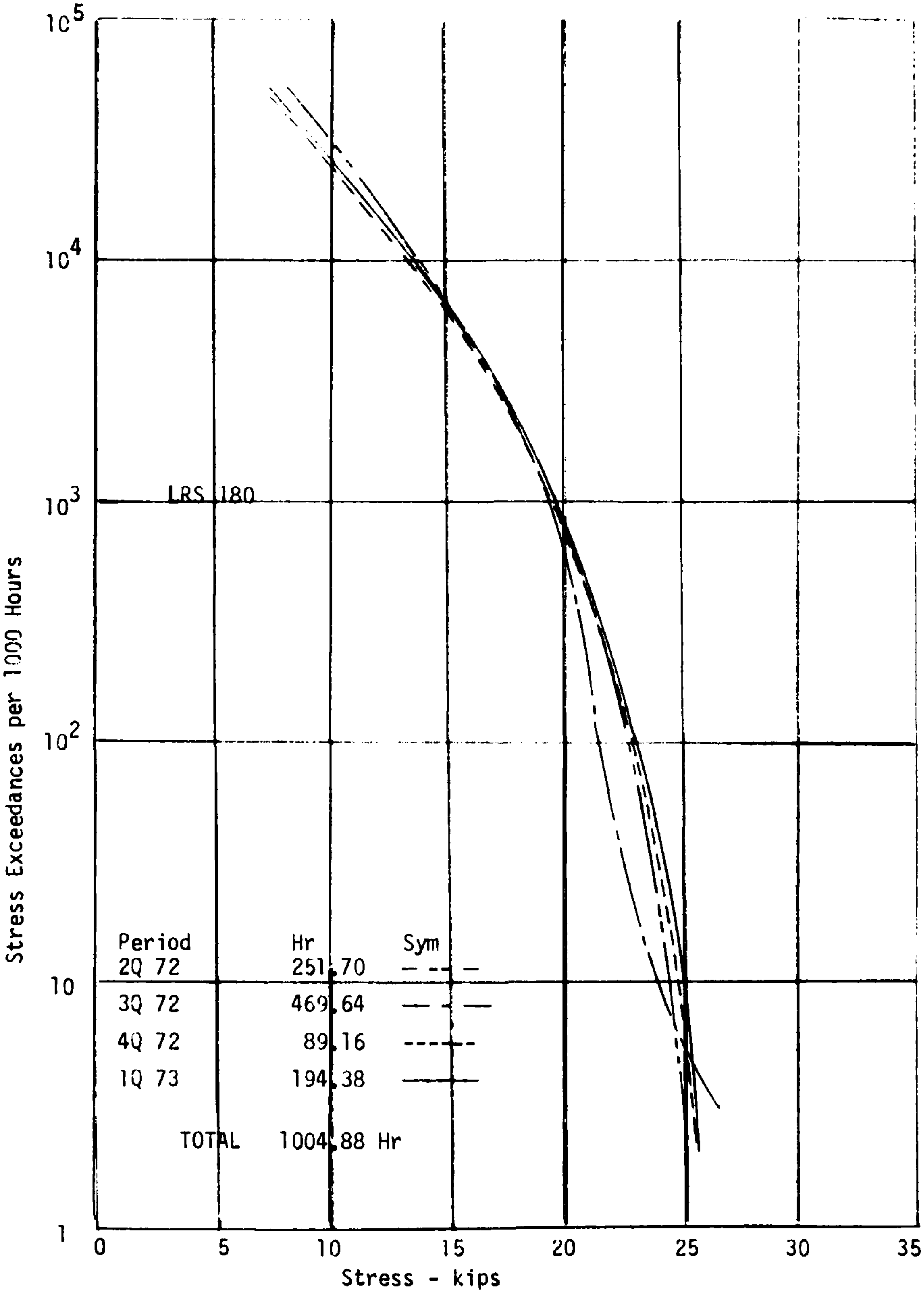


Figure 4. F-4 Spectra - CONUS Air-to-Ground (All Models)

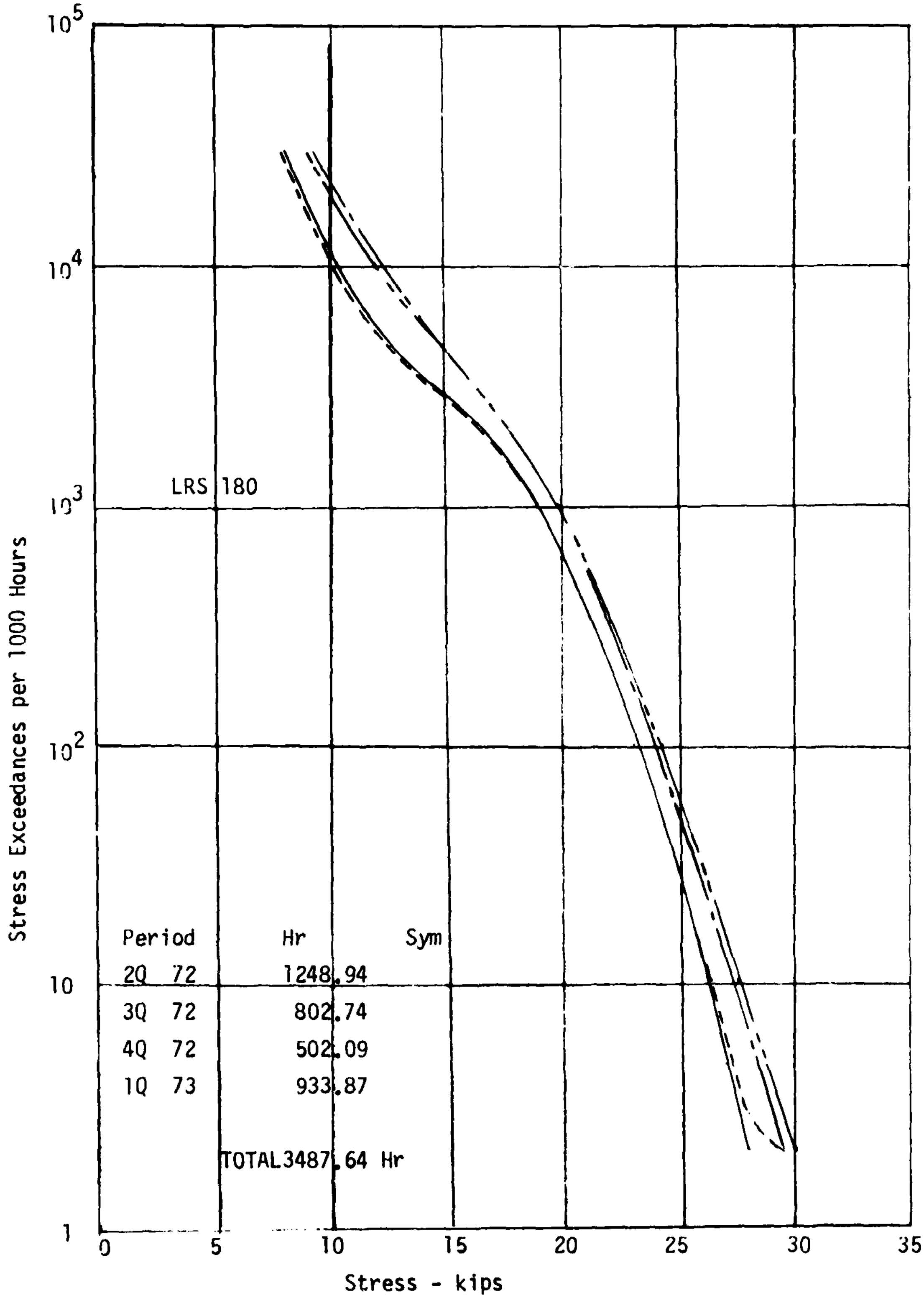


Figure 5. F-4 Spectra - SEA Air-to-Ground (All Models)

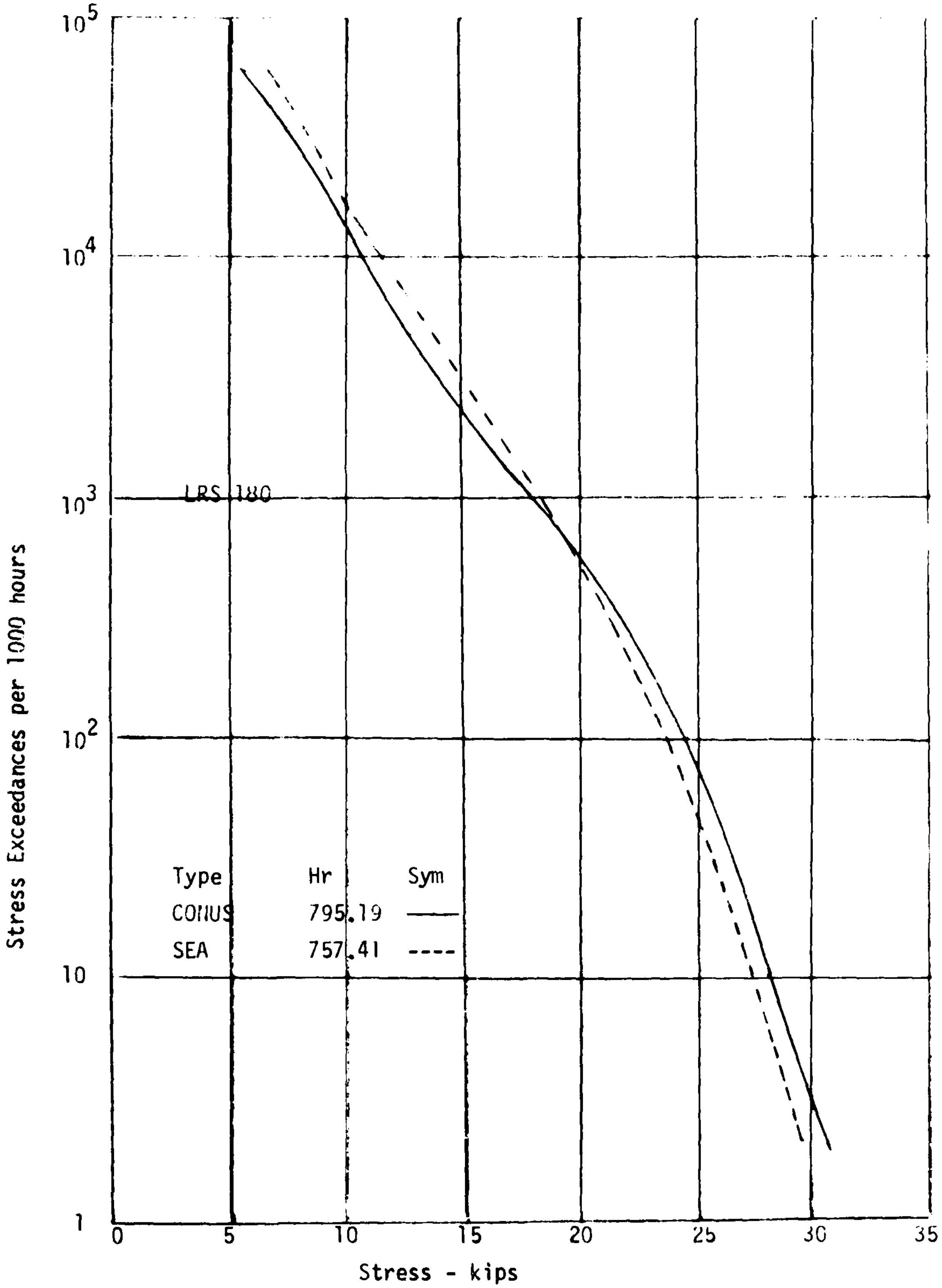


Figure 6. F-4 Spectra - Air-to-Air (All Models) for One Year of VGH Data

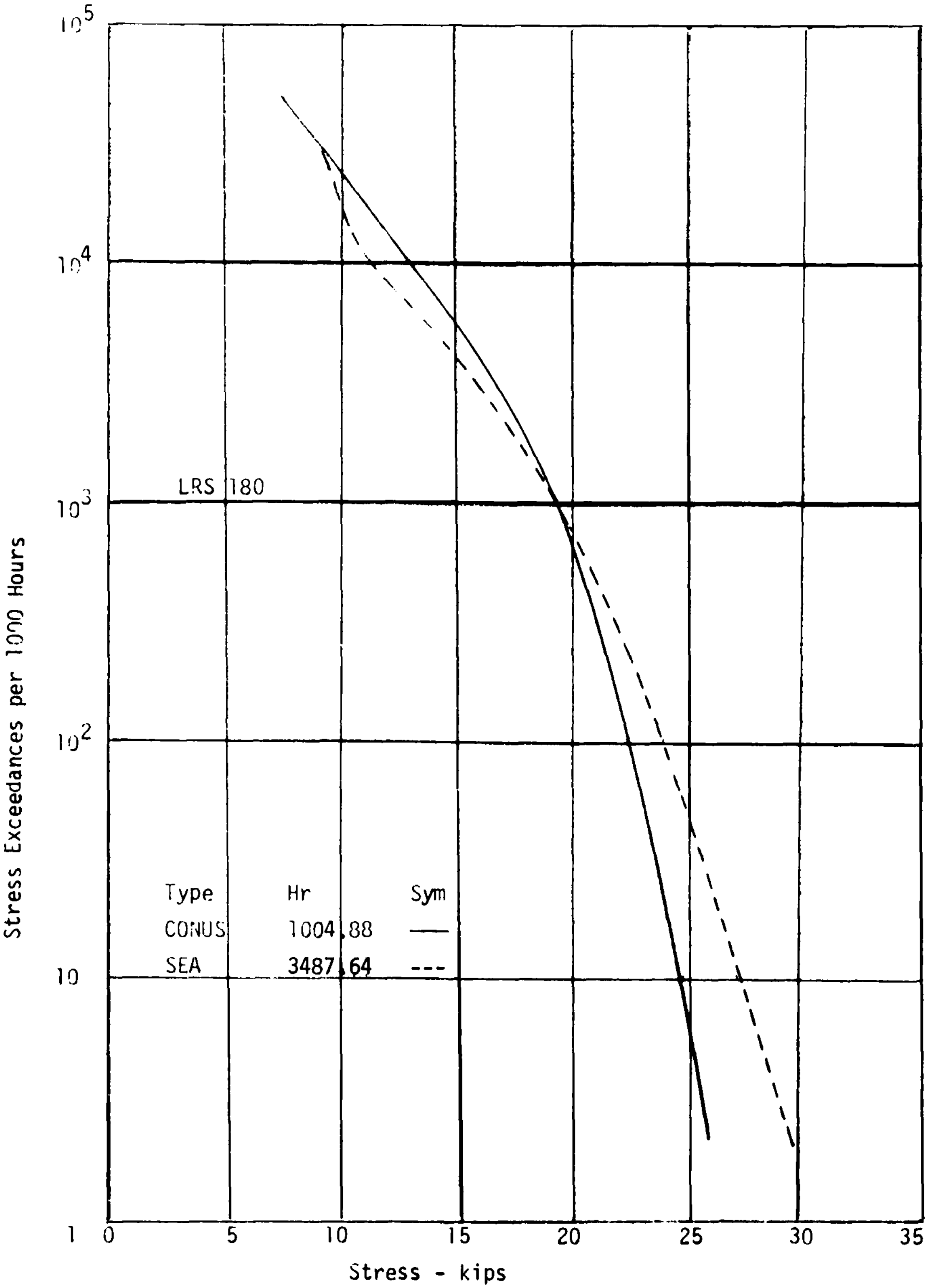


Figure 7. F-4 Spectra - Air-to-Ground (All Models) for One Year of VGH Data

APPENDIX - SPECA PROGRAM LISTING

The listing given below is a FORTRAN extended language routine. This listing contains all of the statements for the version described in the Introduction of this report. Section 3.3 gives a brief description of each of the subroutines in this listing.

```
      PROGRAM SPECA(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)               MAIN  1
C        PROGRAM FOR COMPUTING AIRCRAFT INTERNAL LOAD PROBABILITY        MAIN  2
C        DENSITY FUNCTIONS                                               MAIN  21
C        REVISION 2                                                      MAIN  3
               COMMON P(10000), NTEGER(100), TABL4(2000,2),              MAIN  31
     1   TABL2(500,1)                                                    MAIN  4
               EQUIVALENCE (NTEGER(48), NZERO), (NTEGER(50), NPSCT)      MAIN  5
               NZERO = 0                                                 MAIN  51
               NPSCT = 0                                                 MAIN  6
   10          CALL GUIDE                                                MAIN  7
               GO TO 10                                                  MAIN  8
               END
```

```
              SUBROUTINE GUIDE                                      GIDE   1
C       SUBROUTINE FOR CALLING INPUT DATA AND CALCULATING ROUTINES   GIDE   2
              COMMON F(10000), NTEGER(100), TABL4(2000,2),          GIDE   3
     1  TABL2(500,1)                                                GIDE  31
              EQUIVALENCE (INTEGER(13), NPS)                        GIDE  32
              EQUIVALENCE (INTEGER(48), NZERO)                      GIDE   4
              EQUIVALENCE (P(5), FACTOR)                            GIDE  41
              IF (NZERO) 40, 10                                     GIDE   5
   10         DO   20 I = 1, 10000                                  GIDE   6
   20         P(I) = 0.0                                            GIDE   7
              DO   30 I = 1, 100                                    GIDE   8
   30         NTEGER(I) = 0                                         GIDE  81
              GO TO 44                                              GIDE   9
   40         DO   42 I = 1001, 10000                               GIDE  91
   42         P(I) = 0.0                                            GIDE  92
   44         FACTOR = 1.0                                          GIDE  93
              CALL INPUT                                            GIDE  10
              CALL CALC                                             GIDE  11
              CALL LDLVL                                            GIDE 111
              CALL PRINTP                                           GIDE  12
              IF (NPS) 60, 60, 50                                   GIDE 121
   50         CALL LDCOEF                                           GIDE 122
   60         RETURN                                                GIDE  13
              END                                                   GIDE  14
```

```
              SUBROUTINE IN                                              DEIN   1
C      SUBROUTINE FOR INPUT OF     TANTS, ARRAYS, AND TABLES             DEIN   4
              COMMON F(10000), NTEGER(100), TABL4(2000,2),               DFIN   5
     1 TABL2(500,1)                                                      DEIN  51
              INTEGER MONTH                                              DFIN   6
              DIMENSION  NTB41(2), NTB42(2), NTB43(2), NTB44(2)          DEIN  10
              EQUIVALENCE (P(99), NTTB3)                                 DFIN 101
              EQUIVALENCE (INTEGER(1), IDENT), (INTEGER(2), NPF1),       DFIN  12
     1 (INTEGER(3), NPF2), (INTEGER(4), NPF3), (INTEGER(5), NPF4),       DFIN  13
     2 (INTEGER(6), NTI4), (INTEGER(7), NTW4), (INTEGER(8), MONTH),      DEIN  14
     3 (INTEGER(9), DAY), (INTEGER(10), YEAR), (INTEGER(11), NPSIL),     DEIN  15
     4 (INTEGER(12), NPSILL), (INTEGER(13), NPS), (INTEGER(14), NMORE)   DEIN  16
              EQUIVALENCE (INTEGER(21), NTB)                             DEIN 171
              EQUIVALENCE (INTEGER(49), NPAGE)                           DFIN  18
              EQUIVALENCE (INTEGER(56), NTB41), (INTEGER(58), NTB42),    DEIN 202
     1 (INTEGER(60), NTB43), (INTEGER(62), NTB44)                        DFIN 203
              EQUIVALENCE (INTEGER(64), NTB21), (INTEGER(65), NTB22)     DEIN 204
C      INPUT DATA                                                        DFIN 211
C      NTEGER(1) = IDENT - PROBLEM NUMBER                                DEIN 212
C      NTEGER(2) = NPF1 - THE NUMBER OF SETS OF DATA TO BE READ IN       DEIN 213
C      BY FORMAT 1                                                       DEIN 214
C      NTEGER(3) = NPF2 - THE NUMBER OF PARAMETERS TO BE READ IN         DEIN 215
C      BY FORMAT 2                                                       DEIN 216
C      NTEGER(4) = NPF3 - THE NUMBER OF SETS OF INTEGERS TO BE           DFIN 217
C      READ IN BY FORMAT 3                                               DEIN 218
C      NTEGER(5) = NPF4 - NUMBER OF SETS OF INTEGERS TO BE READ IN       DEIN 219
C      BY FORMAT 4                                                       DFIN 219
C      NTEGER(6) = NTI4 - THE NUMBER OF QUADRUPLE TABLES TO BE READ INDEIN 221
C      NTEGER(7) = NTW4 = 1 FOR QUADRUPLE TABLE PRINT, 0 OTHERWISE       DEIN 222
C      NTEGER(8) = MONTH                                                 DEIN 223
C      NTEGER(9) = DAY                                                   DEIN 224
C      NTEGER(10) = YEAR                                                 DEIN 225
C      NTEGER(11) = NPSIL - THE NUMBER OF INTERNAL LOAD LEVELS USED      DFIN 226
C                FOR INTEGRATION OF JOINT DENSITY FUNCTION               DEIN 227
C      NTEGER(12) - NPSILL - THE NUMBER OF LOAD LEVELS IN  THE           DEIN 228
C                INTERNAL LOAD SPECTRUM                                  DFIN 229
C      NTEGER(13) = NPS - THE NUMBER OF CONTROL POINTS                   DEIN 230
C      NTEGER(14) = NMORE - NUMBER OF ADDITIONAL INTEGERS PLUS 14        DEIN 231
C      NTEGER(15) = NRVI - INDICATED AIRSPEED INTERVAL SUBDIVISION       DEIN 232
C      NTEGER(16) - NRNZ - LOAD FACTOR INTERVAL SUBDIVISIONS             DEIN 233
C      NTEGER(17) - NRH - ALTITUDE INTERVAL SUBDIVISIONS                 DEIN 234
C      NTEGER(18) - NRW - WEIGHT INTERVAL SUBDIVISIONS                   DEIN 235
C      NTEGER(21) = NTB = 1 FOR QUADRUPLE TABLE LOOK UP CASE             DEIN 235
C                     = 2 FOR TRIPLE TABLE LOOK UP CASE                  DEIN 235
C      P(1) - FVI - LEAST UPPER BOUND OF VI IN HISTOGRAM                 DEIN 236
C      P(2) - FNZ - LEAST UPPER BOUND OF NZ IN HISTOGRAM                 DEIN 236
C      P(3) - FH - LEAST UPPER BOUND OF H IN HISTOGRAM                   DEIN 236
C      P(4) - FW - LEAST UPPER BOUND OF W IN HISTOGRAM                   DEIN 236
C      P(5) - FACTOR - LOAD MAGNIFICATION FACTOR                         DEIN 236
C      P(6) - HOURS - NUMBER OF HOURS OF DATA IN HISTOGRAM               DEIN 236
C      P(101) - PSIL(1) - FIRST LOAD LEVEL FOR PROBABILITY CALC.         DEIN 236
C      P(201) - AREAN(1) - FIRST ORD. OF CUM. PROB. FUNC. FOR SPEC.      DFIN 236
              IF (NPS) 10, 10, 2                                         DFIN 236
    2         NPAGE = NPAGE + 1                                          DFIN 237
              GO TO 30                                                   DEIN 238
   10         NPAGE = 1                                                  DEIN 26
C      READ INTEGERS INTO THE PROBLEM                                    DEIN 261
```

```
   30      READ (5,40) (INTEGER(I), I = 1, 14)                    DEIN 262
   40      FORMAT (14I5)                                          DEIN 263
   50      IF (NMORE) 70, 70, 60                                  DEIN 264
   60      READ (5,40) (INTEGER(I), I = 15, NMORE)                DEIN 27
   70      CALL PAGEHO                                            DFIN 28
C       WRITE OUT RUN INFORMATION                                 DFIN 30
   90      READ (5,100)                                           DFIN 31
  100   FORMAT (36H                                               DFIN 32
     1  , 36H                                                     DEIN 33
     2  / 36H                                                     DFIN 34
     3  , 36H                                                     DEIN 35
  110      WRITE (6,100)                                          DEIN 36
  140   FORMAT (6E10.3)                                           DFIN 37
  380      IF (NPF1) 470, 470, 390                                DEIN 68
  390      DO 460  I = 1, NPF1                                    DEIN 69
  400      READ (5,410) NP11, NP22, NP33                          DFIN 70
  410   FORMAT (3I5)                                              DFIN 71
  450      READ (5,140) (P(J), J = NP11, NP22, NP33)              DEIN 75
  460      CONTINUE                                               DFIN 76
C       READ IN PARAMETERS BY FORMAT 2                            DFIN 77
  470      IF (NPF2) 520,520, 480                                 DFIN 78
  485      DO 510  J = 1, NPF2                                    DFIN 79
  490      READ (5,500)   I, P(I)                                 DFIN 80
  500   FORMAT (I5, F15.7)                                        DEIN 81
  510      CONTINUE                                               DFIN 82
C       READ IN INTEGERS BY FORMAT 3                              DFIN 83
  520      IF (NPF3) 611, 611, 530                                DEIN 84
  530      DO 610  I = 1, NPF3                                    DEIN 85
  540      READ (5,550) NNG11, NNG22, NNG33                       DFIN 86
  550   FORMAT (3I5)                                              DEIN 87
  590      READ (5,600) (INTEGER(J), J = NNG11, NNG22, NNG33)     DFIN 91
  600   FORMAT (14I5)                                             DEIN 92
  610      CONTINUE                                               DEIN 93
C       READ IN INTEGERS BY FORMAT 4                              DEIN 931
  611      IF (NPF4) 620, 620, 612                                DEIN 932
  612      DO  613 J = 1, NPF4                                    DEIN 933
  613      READ (5,614) I, NTEGER(I)                              DFIN 934
  614   FORMAT (I5, I15)                                          DEIN 935
C       READ IN QUADRUPLE TABLES                                  DEIN 94
  620      IF (NTI4) 870, 870, 630                                DEIN 95
  630      DO  670 J = 1, NTI4                                    DEIN 96
  640      READ (5,650) I, NTB41(I), NTB42(I), NTB43(I),          DEIN 97
     1  NTB44(I)                                                  DEIN 98
  650   FORMAT (5I10)                                             DEIN 990
           NTT1 = NTB41(I)                                        DCIN 991
           NTT2 = NTB42(I)                                        DEIN 992
           NTT3 = NTB43(I)                                        DEIN 993
           NTT4 = NTB44(I)                                        DFIN 994
           NTP = NTT1 * NTT2 * NTT3 * NTT4                        DEIN 995
           NTT1P1 = NTT1 + 1                                      DEIN 996
           NNTT12 = NTT1 + NTT2                                   DEIN 997
           NN12P1 = NNTT12 + 1                                    DEIN 998
           NNTT13 = NNTT12 + NTT3                                 DEIN 999
           NN13P1 = NNTT13 + 1                                    DEIN1000
           NNTT14 = NNTT13 + NTT4                                 DEIN1001
           NN14P1 = NNTT14 + 1                                    DFIN1002
           NF = NNTT14 + NTP                                      DEIN1003
```

```
          READ (5,140) (TABL4(K,I), K = 1, NTT1)                  DEIN1004
          READ (5,140) (TABL4(K,I), K = NTT1P1, NNTT12)           DEIN1005
          READ (5,140) (TABL4(K,I), K = NN12P1, NNTT13)           DEIN1006
          GO TO (654,656), I                                      DEIN1007
    654   GO TO (656,660), NTB                                    DEIN1008
    656   READ (5,140) (TABL4(K,I), K = NN13P1, NNTT14)           DEIN1009
          READ (5,140) (TABL4( ,I), K = NN14P1, NF)               DEIN1010
          GO TO 670                                               DEIN1011
    660   READ (5,140) NTTB3                                      DEIN1012
          NF = NNTT13 + NTP                                       DEIN1013
          READ (5,140) (TABL4(K,I), K = NN13P1, NF)               DEIN1014
    670   CONTINUE                                                DEIN103
    870   CALL INAIC                                              DEIN109
          RETURN                                                  DEIN110
          END                                                     DEIN111
```

```
              SUBROUTINE INAID                                            INAD   1
C             SUBROUTINE FOR WRITING OUT INPUT DATA                       INAD   2
              COMMON P(10000), NTEGER(100), TABL4(2000,2),                INAD   3
     1        TABL2(500,1)                                                INAD  31
              DIMENSION PSIL(100), AREAN(100), PS(25,25)                  INAD   4
              DIMENSION  NTR41(2), NTR42(2), NTB43(2), NTB44(2)           INAD   5
              EQUIVALENCE (P(1), FVI), (P(2), FNZ), (P(3), FM),           INAD  51
     1        (P(4), FM), (P(5), FACTOR)                                  INAD  52
              EQUIVALENCE (P(99), NITR3)                                  INAD  53
              EQUIVALENCE (P(101), PSIL), (P(201), AREAN),                INAD   6
     1        (P(301), PS)                                                INAD  61
              EQUIVALENCE (INTEGER(7), NTW4), (INTEGER(11), NPSIL),       INAD   7
     1        (INTEGER(12), NPSILL), (INTEGER(13), NPS)                   INAD  71
              EQUIVALENCE (INTEGER(15), NRVI), (INTEGER(16),  NRNZ),      INAD  72
     1        (INTEGER(17), NRH), (INTEGER(18), NRW), (INTEGER(20), NTNZ) INAD  73
              EQUIVALENCE (INTEGER(21), NTR)                              INAD  74
              EQUIVALENCE (INTEGER(48), NZERO), (INTEGER(49), NPAGE),     INAD   8
     1        (INTEGER(50), NPSCT)                                        INAD  81
              EQUIVALENCE (INTEGER(56), NTR41), (INTEGER(58), NTR42),     INAD   9
     1        (INTEGER(60), NTR43), (INTEGER(62), NTB44)                  INAD  91
              EQUIVALENCE (INTEGER(64), NTB21), (INTEGER(65), NTB22)      INAD 100
              WRITE (6,12)                                                INAD 101
   12         FORMAT (/10X, 22HHISTOGRAM SUBDIVISIONS )                   INAD 102
              WRITE (6,14) NRVI, NRNZ, NRH, NRW                           INAD 103
   14         FORMAT (10X, 6HNRVI =, I5 /                                 INAD 104
     1                10X, 6HNRNZ =, I5 /                                 INAD 105
     1                10X, 6HNRH  =, I5 /                                 INAD 106
     1                10X, 6HNRW  =, I5 )                                 INAD 107
              WRITE (6,16) FACTOR                                         INAD 108
   16         FORMAT (//10X, 27HLOAD MAGNIFICATION FACTOR =, F10.4 )      INAD 109
              WRITE (6,18)                                                INAD  11
   18         FORMAT (/10X,62HINTERNAL LOAD LEVELS FOR INTEGRATION OF JOINT DINAD  12
     1ENSITY FUNCTION )                                                   INAD  13
              DO   20 I = 1, NPSIL, 4                                     INAD  14
              IP1 = I + 1                                                 INAD  15
              IP2 = I + 2                                                 INAD  16
              IP3 = I + 3                                                 INAD  17
   20         WRITE (6,30) I, PSIL(I), IP1, PSIL(IP1),                    INAD  18
     1        IP2, PSIL(IP2), IP3, PSIL(IP3)                              INAD  19
   30         FORMAT (I15, 1PE15.5, I10, 1PE15.5, I10, 1PE15.5, I10, 1PE15.5)INAD  20
              WRITE (6,32)                                                INAD 201
   32         FORMAT (/10X, 53HCUMULATIVE AREAS OF LOAD PROBABILITY DENSITY FINAD 202
     1UNCTION / 10X, 24HFOR SPECTRUM LOAD LEVELS )                        INAD 203
              DO   34 I = 1, NPSILL, 4                                    INAD 204
              I1 = I + 1                                                  INAD 205
              I2 = I + 2                                                  INAD 206
              I3 = I + 3                                                  INAD 207
   34         WRITE (6,36) I, AREAN(I), I1, AREAN(I1),                    INAD 208
     1        I2, AREAN(I2), I3, AREAN(I3)                                INAD 209
   36         FORMAT (I15, 1PE15.5, I10, 1PE15.5, I10, 1PE15.5, I10, 1PE15.5)INAD 210
              IF (NPSCT) 39, 39, 37                                       INAD 211
   37         NPAGE = NPAGE + 1                                           INAD 212
              CALL PAGEHD                                                 INAD 213
              WRITE (6,370)                                               INAD 214
  370         FORMAT (/10X, 30HBALANCED LOAD CONDITION MATRIX )           INAD 215
              DO   38 I = 1, NPS                                          INAD 216
   38         WRITE (6,380) (PS(I,J), J = 1, NPS)                         INAD 217
```

```
  386  FORMAT (1P8E15.6)                                          INAD 218
  39         IF (NTM4) 150, 150, 40                               INAD 219
  40         DO  130 I = 1, 2                                     INAD 22
  45         IF (NTB41(I)) 50, 130                                INAD 23
  50         NTT1 = NTB41(I)                                      INAD 24
             NTT2 = NTB42(I)                                      INAD 25
             NTT3 = NTB43(I)                                      INAD 26
             NTT4 = NTB44(I)                                      INAD 27
             NTP = NTT1 * NTT2 * NTT3 * NTT4                      INAD 28
             NTT1P1 = NTT1 + 1                                    INAD 29
             NNTT12 = NTT1 + NTT2                                 INAD 30
             NN12P1 = NNTT12 + 1                                  INAD 31
             NNTT13 = NNTT12 + NTT3                               INAD 32
             NN13P1 = NNTT13 + 1                                  INAD 33
             NNTT14 = NNTT13 + NTT4                               INAD 34
             NN14P1 = NNTT14 + 1                                  INAD 35
             NF = NNTT14 + NTP                                    INAD 36
             NPAGE = NPAGE + 1                                    INAD 37
             CALL PAGEHD                                          INAD 38
             GO TO (52,62), I                                     INAD 39
  52         WRITE (6,60)                                         INAD 40
  60   FORMAT (/10X, 21HCUADRUPLE TABLE NO. 1 / 10X,              INAD 41
     1      19HPSI VS VI, NZ, H, W )                              INAD 42
             GO TO 72                                             INAD 43
  62         WRITE (6,64)                                         INAD 44
  64   FORMAT (/10X, 21HCUADRUPLE TABLE NO. 2 / 10X,              INAD 45
     1      21HHISTJ VS VI, NZ, H, W )                            INAD 46
  66         WRITE (6,70) (TABL4(J,I), J = 1, NTT1)               INAD 47
  70   FORMAT (10X, 2HVI / (12F9.1))                              INAD 48
             GO TO 76                                             INAD 481
  72         WRITE (6,73) (TABL4(J,I), J = 1, NTT1)               INAD 482
  73   FORMAT (10X, 2HVI / (12F9.1))                              INAD 483
  76         WRITE (6,80) (TABL4(J,I), J = NTT1P1, NNTT12)        INAD 49
  80   FORMAT (10X, 2HNZ / (12F9.4))                              INAD 50
             WRITE (6,90) (TABL4(J,I), J = NN12P1, NNTT13)        INAD 51
  90   FORMAT (10X, 1HH / (12F9.0))                               INAD 52
             GO TO (94,96), I                                     INAD 521
  94         GO TO (96,98), NTB                                   INAD 522
  96         WRITE (6,100) (TABL4(J,I), J = NN13P1, NNTT14)       INAD 53
             GO TO 101                                            INAD 531
  98         WRITE (6,100) NTTB3                                  INAD 532
  100  FORMAT (10X, 1HW / (12F9.0))                               INAD 54
  101        GO TO (102,112), I                                   INAD 55
  102        GO TO (104,106), NTB                                 INAD 56
  104        WRITE (6,110) (TABL4(J,I), J = NN14P1, NF)           INAD 561
             GO TO 130                                            INAD 562
  106        NF = NNTT13 + NTP                                    INAD 563
             WRITE (6,110) (TABL4(J,I), J = NN13P1, NF)           INAD 564
  110  FORMAT (10X, 3HPSI / (12F10.0))                            INAD 57
             GO TO 130                                            INAD 58
  112        WRITE (6,120) (TABL4(J,I), J = NN14P1, NF)           INAD 59
  120  FORMAT (10X, 5HHISTJ / (12F10.0))                          INAD 60
  130        CONTINUE                                             INAD 61
  140        IF (NTB41(2)) 150, 150, 142                          INAD 63
  142        WRITE (6,144) FVI, FNZ, FH, FW                       INAD 64
  144  FORMAT (/10X, 25HLAST ABSCISSAS IN TABLE 2  /              INAD 65
     1       10X, 8HFVI =    , E15.6 /                            INAD 66
```

```
 115      1     10X, 8HFNZ =     , E15.6 /                INAD 67
          3     10X, 8HFH =      , E15.6 /                INAD 68
                10X, 8HFH =      , E15.6 )                INAD 69
          4     NZERO = 1                                 INAD 89
         150    RETURN                                    INAD 90
                END                                       INAD 91
 120
```

```
SUBROUTINE CALC      74/74   OPT=1                    FTN 4.0+P353      11/02/73  09.05.28.      PAGE    1

                SUBROUTINE CALC                                                  CALC   1
C       SUBROUTINE FOR COMPUTING PROBABILITY DENSITY FUNCTIONS                   CALC   2
                COMMON F(10000), NTEGER(100), TABL4(2000,2),                     CALC   3
        1 TABL2(500,1)                                                           CALC  31
                REAL   NZ, NT, NZI(25), NTR                                      CALC   4
                DIMENSION PSIL(100), PPSI(100), PDPSI(100), A(3,4),              CALC   5
        1 Y(3,1)                                                                 CALC  51
                DIMENSION HI(25), WI(25), VII(25)                                CALC  52
                DIMENSION  NTB41(2), NTB42(2), NTB43(2), NTB44(2)                CALC   6
                EQUIVALENCE (P(1), FVI), (P(2), FNZ), (P(3), FH),                CALC  61
        1 (P(4), FW), (P(5), FACTOR)                                             CALC  62
                EQUIVALENCE (P(100), NT)                                         CALC  63
                EQUIVALENCE (P(101), PSIL), (P(1001), PPSI),                     CALC  63
        1 (P(1101), PDPSI)                                                       CALC  65
                EQUIVALENCE (P(5001), VII), (P(5026), NZI),                      CALC  65
        1 (P(5051), HI), (P(5076), WI)                                           CALC  66
                EQUIVALENCE (INTEGER(11), NPSIL)                                 CALC  71
                EQUIVALENCE (INTEGER(15), NRVI), (INTEGER(16), NRNZ),            CALC  72
        1 (INTEGER(17), NRH), (INTEGER(18), NRW)                                 CALC  73
                EQUIVALENCE (INTEGER(21), NTB)                                   CALC  74
                EQUIVALENCE (INTEGER(56), NTB41), (INTEGER(58), NTB42),          CALC   8
        1 (INTEGER(60), NTB43), (INTEGER(62), NTB44)                             CALC   9
                EQUIVALENCE (INTEGER(64), NTB21), (INTEGER(65), NTB22)           CALC  91
C       COMPUTE THE TOTAL NUMBER OF OCCURRENCES FROM HISTJ                       CALC  10
                NP12 = NTB41(1) * NTB42(1)                                       CALC 101
                NP13 = NP12 * NTB43(1)                                           CALC 102
                NN14 = NTB41(1) + NTB42(1) + NTB43(1) + NTB44(1)                 CALC 103
                NN22 = NTB41(2) + NTB42(2)                                       CALC  11
                NN23 = NN22 + NTB43(2)                                           CALC  12
                NN24 = NN23 + NTB44(2)                                           CALC  13
                NP22 = NTB41(2) * NTB42(2)                                       CALC 131
                NP23 = NP22 * NTB43(2)                                           CALC 132
                NP24 = NP23 * NTB44(2)                                           CALC  14
                NN24P1 = NN24 + 1                                                CALC  15
                NNP24 = NN24 + NP24                                              CALC  16
                NT = 0.0                                                         CALC  17
                DO   10 I = NN24P1, NNP24                                        CALC  18
           10   NT = TABL4(I,2) + NT                                             CALC 181
                RVI = NRVI                                                       CALC 182
                RNZ = NRNZ                                                       CALC 183
                RH = NRH                                                         CALC 184
                RW = NRW                                                         CALC 185
                NTR = NT * RVI * RNZ * RH * RW                                   CALC 186
                NT421 = NTB41(2)                                                 CALC 190
                NT422 = NTB42(2)                                                 CALC 191
                NT423 = NTB43(2)                                                 CALC 192
                NT424 = NTB44(2)                                                 CALC 193
                DO   12 I = 1, NT421                                             CALC 194
           12   VII(I) = TABL4(I,2)                                              CALC 195
                VII(NT421+1) = FVI                                               CALC 196
                DO   14 J = 1, NT422                                             CALC 197
                JTB = J + NTB41(2)                                               CALC 198
           14   NZI(J) = TABL4(JTB,2)                                            CALC 199
                NZI(NT422+1) = FNZ                                               CALC 200
                DO   16 K = 1, NT423                                             CALC 201
                KTB = K + NN22                                                   CALC 202
           16   HI(K) = TABL4(KTB,2)                                             CALC 203
```

```
          WI(NT423+1) = FW                                             CALC 204
          DO   18 M = 1, NT424                                         CALC 205
          NTR = M + NN23                                               CALC 206
   18     WI(M) = TABL4(NTR,2)                                         CALC 207
          WI(NT424+1) = FW                                             CALC 208
          DO   30 I = 1, NT421                                         CALC 209
          DO   30 J = 1, NT422                                         CALC 21
          DO   30 K = 1, NT423                                         CALC 22
          DO   30 M = 1, NT424                                         CALC 23
          N2222 = NN24 + (M - 1) * NP23 + (K - 1) * NP22               CALC 231
     1    * (J - 1) * NTB41(2) + I                                     CALC 232
          PJT = TABL4(N2222,2) / NTR                                   CALC 233
          DO   30 IR = 1, NRVI                                         CALC 24
          DO   30 JR = 1, NRNZ                                         CALC 25
          DO   30 KR = 1, NRH                                          CALC 26
          DO   30 MR = 1, NRW                                          CALC 27
          RIR = IR                                                     CALC 271
          RJR = JR                                                     CALC 272
          RKR = KR                                                     CALC 273
          RMR = MR                                                     CALC 274
          RATIR = (RIR - 0.5) / RVI                                    CALC 28
          RATJR = (RJR - 0.5) / RNZ                                    CALC 29
          RATKR = (RKR - 0.5) / RH                                     CALC 30
          RATMR = (RMR - 0.5) / RW                                     CALC 31
          VI = VII(I) + RATIR * (VII(I+1) - VII(I))                    CALC 32
          NZ = NZI(J) + RATJR * (NZI(J+1) - NZI(J))                    CALC 35
          H = HI(K) + RATKR * (HI(K+1) - HI(K))                        CALC 38
          W = WI(M) + RATMR * (WI(M+1) - WI(M))                        CALC 41
          GO TO (200, 300), NTR                                        CALC 421
  200     CALL TAFO (TABL4(1,1), VI, NZ, H, W, CSI, NTB41(1),          CALC 43
     1    NTB42(1), NTB43(1), NTB44(1) )                               CALC 44
          GO TO 19                                                     CALC 45
  300     CALL TART (TABL4(1,1), VI, NZ, H, CSI, NTB41(1),             CALC 46
     1    NTB42(1), NTB43(1) )                                         CALC 47
   19     PSI = CSI * FACTOR                                           CALC 50
          DO   30 II = 1, NPSIL                                        CALC 501
          IF(PSI - PSIL(II)) 30, 20, 20                                CALC 51
   20     PPSI(II) = PJT + PPSI(II)                                    CALC 52
   30     CONTINUE                                                     CALC 53
          NPLM2 = NPSIL - 2                                            CALC 54
          DO  130 I = 1, NPLM2                                         CALC 55
          I1 = I + 1                                                   CALC 56
          I2 = I + 2                                                   CALC 57
          A(1,1) = PSIL(I) **2                                         CALC 58
          A(1,2) = PSIL(I)                                             CALC 59
          A(1,3) = 1.0                                                 CALC 60
          A(2,1) = PSIL(I1) **2                                        CALC 61
          A(2,2) = PSIL(I1)                                            CALC 62
          A(2,3) = 1.0                                                 CALC 63
          A(3,1) = PSIL(I2) **2                                        CALC 64
          A(3,2) = PSIL(I2)                                            CALC 65
          A(3,3) = 1.0                                                 CALC 66
          A(1,4) = - PPSI(I)                                           CALC 67
          A(2,4) = - PPSI(I1)                                          CALC 68
          A(3,4) = - PPSI(I2)                                          CALC 69
          CALL GAUSS2(3,1,1.0E-07,A,X,K3)                              CALC 70
          IF (K3-1) 60, 80, 60                                         CALC 71
```

```
  60      WRITE (6,70) K3                                          CALC 72
  70 FORMAT (10X, 26HGAUSS2 ERROR SIGNAL + K3 = , I3)              CALC 73
  80      IF (I-1) 140, 100, 90                                    CALC 74
  90      IF (I-NPLP2) 120, 110, 140                               CALC 75
 100      PDPSI(I) = 2.0 * X(1) * PSIL(I) + X(2)                   CALC 76
          GO TO 120                                                CALC 77
 110      PDPSI(I2) = 2.0 * X(1) * PSIL(I2) + X(2)                 CALC 78
 120      PDPSI(I1) = 2.0 * X(1) * PSIL(I1) + X(2)                 CALC 79
 130      CONTINUE                                                 CALC 80
 140      RETURN                                                   CALC 81
          END                                                      CALC 82
```

```
                    SUBROUTINE LDLVL                                              LDLV   1
      C       SUBROUTINE FOR COMPUTING INTERNAL LOAD LEVELS FOR                   LDLV   2
      C       A GIVEN DISTRIBUTION OF LOAD CYCLES                                 LDLV   3
                    COMMON P(10000), NTEGER(100), TABL4(2000,2),                  LDLV   4
            1 TABL2(500,1)                                                        LDLV  41
                    DIMENSION PPSI(100), APDPSI(100),                             LDLV   5
            1 PSILL(100), AREAN(100), PSIL(100), FRAC(100)                        LDLV   6
                    EQUIVALENCE (P(101), PSIL),                                   LDLV   7
            1 (P(201), AREAN), (P(1001), PPSI), (P(1201), APDPSI),                LDLV   8
            2 (P(1301), PSILL), (P(1401), FRAC)                                   LDLV   9
                    EQUIVALENCE (NTEGER(11), NPSIL), (NTEGER(12), NPSILL)         LDLV  10
                    DELTA = PSIL(2) - PSIL(1)                                     LDLV 101
                    DO   10 J= 1, NPSIL                                           LDLV  11
           10       APDPSI(J) = 1.0 - PPSI(J)                                     LDLV  12
                    IF (AREAN(1) - APDPSI(1)) 20, 50, 50                          LDLV  13
           20       WRITE (6,30)                                                  LDLV  14
           30 FORMAT (10X, 44HERROR MESSAGE - AREAN(1) LESS THAN APDPSI(1) )      LDLV  15
                    CALL PRINTR                                                   LDLV  16
           50       IF (AREAN(NPSILL) - APDPSI(NPSIL)) 90, 90, 60                 LDLV  18
           60       WRITE (6,70)                                                  LDLV  19
           70 FORMAT (10X, 56HERROR MESSAGE - AREAN(NPSILL) GREATER THAN APDPLDLV  20
             1SI(NPSIL) )                                                         LDLV  21
                    CALL PRINTR                                                   LDLV  22
           90       DO  180 J = 1, NPSILL                                         LDLV  24
                    DO  170 I = 1, NPSIL                                          LDLV  25
                    IF (AREAN(J) - APDPSI(I)) 110, 100, 170                       LDLV  26
          100       PSILL(J) = PSIL(I)                                            LDLV  27
                    GO TO 180                                                     LDLV  28
          110       IF (I-1) 120, 120, 130                                        LDLV  29
          120       P1 = APDPSI(1)                                                LDLV  30
                    P2 = APDPSI(2)                                                LDLV  31
                    P3 = APDPSI(3)                                                LDLV  32
                    GO TO 140                                                     LDLV  33
          130       P1 = APDPSI(I-1)                                              LDLV  34
                    P2 = APDPSI(I)                                                LDLV  35
                    P3 = APDPSI(I+1)                                              LDLV  36
          140       A = 0.5 * P1 - P2 + 0.5 * P3                                  LDLV  37
                    B = - 0.5 * P1 + 0.5 * P3                                     LDLV  38
                    C = P2 - AREAN(J)                                             LDLV  39
                    DISC = B **2 - 4.0 * A * C                                    LDLV 391
                    IF (DISC) 142, 144, 144                                       LDLV 392
          142       WRITE (6,143) DISC                                            LDLV 393
          143 FORMAT (10X, 6HDISC =, E15.6)                                       LDLV 394
                    CALL PRINTR                                                   LDLV 395
          144       ETA = (- B + SQRT(DISC))/(2.0 * A)                            LDLV  40
                    IF (I-1) 150, 150, 160                                        LDLV  41
          150       PSILL(J) = PSIL(2) + ETA * DELTA                              LDLV  42
                    GO TO 180                                                     LDLV  43
          160       PSILL(J) = PSIL(I) + ETA * DELTA                              LDLV  44
                    GO TO 180                                                     LDLV  45
          170       CONTINUE                                                      LDLV 451
          180       CONTINUE                                                      LDLV 452
                    NPR = NPSILL - 1                                              LDLV 453
                    FRAC(1) = (AREAN(1) + AREAN(2)) / 2.0                         LDLV 454
                    DO  190 I = 2, NPR                                            LDLV 455
          190       FRAC(I) = (AREAN(I+1) - AREAN(I-1)) / 2.0                     LDLV 456
                    FRAC(NPSILL) = 1.0 - (AREAN(NPSILL) +                         LDLV 457
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```
        1  AREA(NPSILL-1)) / 2.0                    LDLV 458
              RETURN                                LDLV 46
   60         END                                   LDLV 47
```

```
            SUBROUTINE LOCOEF
C     SUBROUTINE FOR COMPUTING THE LOAD CONDITION COEFFICIENTS
            COMMON P(10900), INTEGER(100), TABLE(2000,2),
     1      TABL2(500,1)
            DIMENSION PSILL(100), PS(25,25), ALPHA(25),
     1      PLOS(100,25), A(25,50), AINV(25,25), PLD(25)
            EQUIVALENCE (P(301), PS), (P(1301), PSILL),
     1      (P(1501), PLOS), (P(4001), ALPHA)
            EQUIVALENCE (INTEGER(12), NPSILL), (INTEGER(13), NPS),
     1      (INTEGER(43), NPAGE), (INTEGER(50), NPSCT)
            NPSCT = NPSCT + 1
            DO  10 I = 1, NPSILL
   10       PLOS(I,NPSCT) = PSILL(I)
            IF (NPSCT - NPS) 130, 20, 20
   20       DO   50 I = 1, NPS
            DO   50 J = 1, NPS
            A(I,J) = PS(I,J)
            JNPS = J + NPS
            IF (I - J) 40, 30, 40
   30       A(I,JNPS) = 1.0
            GO TO 50
   40       A(I,JNPS) = 0.0
   50       CONTINUE
            CALL GAUS21 (NPS, NPS, 1.0E-07, A, AINV, K3)
            IF (K3 - 1) 60, 75, 60
   60       WRITE (6,70) K3
   70 FORMAT (10X, 26HGAUS21 ERROR SIGNAL - K3 = , I3 )
   75       NPAGE = NPAGE + 1
            CALL PAGEED
            DO  120 I = 1, NPSILL
            DO   80 J = 1, NPS
   80       PLD(J) = PLOS(I,J)
            DO   90 K = 1, NPS
            ALPHA(K) = 0.0
            DO   90 L = 1, NPS
   90       ALPHA(K) = AINV(K,L) * PLD(L) + ALPHA(K)
            WRITE (6,100) I
  100 FORMAT (/10X, 36HCOEFFICIENTS FOR FREQUENCY LEVEL NO. , I5 )
            WRITE (6,110) (ALPHA(IA), IA = 1, NPS)
  110 FORMAT (1P8E15.6)
  120       CONTINUE
  130       RETURN
            END
```

```
                SUBROUTINE TART (TABLE,X1ARG, X2ARG, X3ARG,                TTAB   1
     1  AMP, NTAB1, NTAB2, NTAB3)                                          TTAB   2
C       SUBROUTINE FOR STRAIGHT LINE INTERPOLATION IN A TRIPLE             TTAB   3
C       TABLE LOOK UP                                                      TTAB   4
                DIMENSION TABLE (2000)                                     TTAB   5
                DO   10 I1 = 1, NTAB1                                      TTAB   6
                IF (TABLE(I1) - X1ARG) 10, 20, 20                          TTAB   7
   10           CONTINUE                                                   TTAB   8
                I1 = NTAB1                                                 TTAB   9
   20           IF (I1 - 1) 30, 30, 40                                     TTAB  10
   30           I1 = 2                                                     TTAB  11
   40           NT1P1 = NTAB1 + 1                                          TTAB  12
                NN12 = NTAB1 + NTAB2                                       TTAB  13
                DO   50 I2 = NT1P1, NN12                                   TTAB  14
                IF (TABLE(I2) - X2ARG) 50, 60, 60                          TTAB  15
   50           CONTINUE                                                   TTAB  16
                I2 = NN12                                                  TTAB  17
   60           IF (I2 - NT1P1) 70, 70, 80                                 TTAB  18
   70           I2 = NTAB1 + 2                                             TTAB  19
   80           NT2P1 = NN12 + 1                                           TTAB  20
                NN13 = NN12 + NTAB3                                        TTAB  21
                DO   90 I3 = NT2P1, NN13                                   TTAB  22
                IF (TABLE(I3) - X3ARG) 90, 100, 100                        TTAB  23
   90           CONTINUE                                                   TTAB  24
                I3 = NN13                                                  TTAB  25
  100           IF (I3 - NT2P1) 110, 110, 120                              TTAB  26
  110           I3 = NN12 + 2                                              TTAB  27
  120           NP12 = NTAB1 * NTAB2                                       TTAB  28
                NP13 = NP12 * NTAB3                                        TTAB  29
                N222 = NN13 + (I3 - NN12 - 1) * NP12 +                     TTAB  30
     1  (I2 - NTAB1 - 1) * NTAB1 + I1                                      TTAB  31
                N122 = N222 - 1                                            TTAB  32
                N212 = N222 - NTAB1                                        TTAB  33
                N112 = N212 - 1                                            TTAB  34
                N221 = N222 - NP12                                         TTAB  35
                N121 = N221 - 1                                            TTAB  36
                N211 = N221 - NTAB1                                        TTAB  37
                N111 = N211 - 1                                            TTAB  38
                X1RAT = (X1ARG - TABLE(I1-1)) /                            TTAB  39
     1  (TABLE(I1) - TABLE(I1-1))                                          TTAB  40
                X2RAT = (X2ARG - TABLE(I2-1)) /                            TTAB  41
     1  (TABLE(I2) - TABLE(I2-1))                                          TTAB  42
                X3RAT = (X3ARG - TABLE(I3-1)) /                            TTAB  43
     1  (TABLE(I3) - TABLE(I3-1))                                          TTAB  44
                AMP11 = TABLE(N111) + X1RAT * (TABLE(N211) -               TTAB  45
     1  TABLE(N111))                                                       TTAB  46
                AMP21 = TABLE(N121) + X1RAT * (TABLE(N221) -               TTAB  47
     1  TABLE(N121))                                                       TTAB  48
                AMP12 = TABLE(N112) + X1RAT * (TABLE(N212) -               TTAB  49
     1  TABLE(N112))                                                       TTAB  50
                AMP22 = TABLE(N122) + X1RAT * (TABLE(N222) -               TTAB  51
     1  TABLE(N122))                                                       TTAB  52
                AMP1 = AMP11 + X2RAT * (AMP21 - AMP11)                     TTAB  53
                AMP2 = AMP12 + X2RAT * (AMP22 - AMP12)                     TTAB  54
                AMP = AMP1 + X3RAT * (AMP2 - AMP1)                         TTAB  55
                RETURN                                                     TTAB  56
                END                                                        TTAB  57
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```
                  SUBROUTINE TABQ (TABLE,X1ARG, X2ARG,X3ARG,             QTAB  1
     1  X4ARG, AMP, NTAB1, NTAB2, NTAB3, NTAB4)                          QTAB  2
C       SUBROUTINE FOR STRAIGHT LINE INTERPOLATION IN A QUADRUPLE        QTAB  3
C       TABLE LOOK UP                                                    QTAB  4
                  DIMENSION TABLE (2000)                                 QTAB  5
                  DO   10 I1 = 1, NTAB1                                  QTAB  6
                  IF (TABLE(I1) - X1ARG) 10, 20, 20                      QTAB  7
   10             CONTINUE                                               QTAB  8
                  I1 = NTAB1                                             QTAB  9
   20             IF (I1 - 1) 30, 30, 40                                 QTAB 10
   30             I1 = 2                                                 QTAB 11
   40             NT1P1 = NTAB1 + 1                                      QTAB 12
                  NN12 = NTAB1 + NTAB2                                   QTAB 13
                  DO   50 I2 = NT1P1, NN12                               QTAB 14
                  IF (TABLE(I2) - X2ARG) 50, 60, 60                      QTAB 15
   50             CONTINUE                                               QTAB 16
                  I2 = NN12                                              QTAB 17
   60             IF (I2 - NT1P1) 70, 70, 80                             QTAB 18
   70             I2 = NTAB1 + 2                                         QTAB 19
   80             NT2P1 = NN12 + 1                                       QTAB 20
                  NN13 = NN12 + NTAB3                                    QTAB 21
                  DO   90 I3 = NT2P1, NN13                               QTAB 22
                  IF (TABLE(I3) - X3ARG) 90, 100, 100                    QTAB 23
   90             CONTINUE                                               QTAB 24
                  I3 = NN13                                              QTAB 25
  100             IF (I3 - NT2P1) 110, 110, 120                          QTAB 26
  110             I3 = NN12 + 2                                          QTAB 27
  120             NT3P1 = NN13 + 1                                       QTAB 28
                  NN14  = NN13 + NTAB4                                   QTAB 29
                  DO  130 I4 = NT3P1, NN14                               QTAB 30
                  IF (TABLE(I4) - X4ARG) 130, 140, 140                   QTAB 31
  130             CONTINUE                                               QTAB 32
                  I4 = NN14                                              QTAB 33
  140             IF (I4 - NT3P1) 150, 150, 160                          QTAB 34
  150             I4 = NN13 + 2                                          QTAB 35
  160             NP12 = NTAB1 * NTAB2                                   QTAB 36
                  NP13 = NP12 * NTAB3                                    QTAB 37
                  N2222 = NN14 + (I4 - NN13 - 1) * NP13 +                QTAB 38
     1  (I3 - NN12 - 1) * NP12 + (I2 - NTAB1 - 1) * NTAB1 + I1           QTAB 39
                  N1222 = N2222 - 1                                      QTAB 40
                  N2122 = N2222 - NTAB1                                  QTAB 41
                  N1122 = N2122 - 1                                      QTAB 42
                  N2212 = N2222 - NP12                                   QTAB 43
                  N1212 = N2212 - 1                                      QTAB 44
                  N2112 = N2212 - NTAB1                                  QTAB 45
                  N1112 = N2112 - 1                                      QTAB 46
                  N2221 = N2222 - NP13                                   QTAB 47
                  N1221 = N2221 - 1                                      QTAB 48
                  N2121 = N2221 - NTAB1                                  QTAB 49
                  N1121 = N2121 - 1                                      QTAB 50
                  N2211 = N2221 - NP12                                   QTAB 51
                  N1211 = N2211 - 1                                      QTAB 52
                  N2111 = N2211 - NTAB1                                  QTAB 53
                  N1111 = N2111 - 1                                      QTAB 54
                  X1RAT = (X1ARG - TABLE(I1-1)) /                        QTAB 55
     1  (TABLE(I1) - TABLE(I1-1))                                        QTAB 56
                  X2RAT = (X2ARG - TABLE(I2-1)) /                        QTAB 57
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```
     1 (TABLE(I2) - TABLE(I2-1))                                        QTAB 58
          X3RAT = (X3ARG - TABLE(I3-1)) /                               QTAB 59
     1 (TABLE(I3) - TABLE(I3-1))                                        QTAB 60
          X4RAT = (X4ARG - TABLE(I4-1)) /                               QTAB 61
     1 (TABLE(I4) - TABLE(I4-1))                                        QTAB 62
          AMP111 = TABLE(N1111) + X1RAT * (TABLE(N2111) -               QTAB 63
     1 TABLE(N1111))                                                    QTAB 64
          AMP211 = TABLE(N1211) + X1RAT * (TABLE(N2211) -               QTAB 65
     1 TABLE(N1211))                                                    QTAB 66
          AMP121 = TABLE(N1121) + X1RAT * (TABLE(N2121) -               QTAB 67
     1 TABLE(N1121))                                                    QTAB 68
          AMP221 = TABLE(N1221) + X1RAT * (TABLE(N2221) -               QTAB 69
     1 TABLE(N1221))                                                    QTAB 70
          AMP112 = TABLE(N1112) + X1RAT * (TABLE(N2112) -               QTAB 71
     1 TABLE(N1112))                                                    QTAB 72
          AMP212 = TABLE(N1212) + X1RAT * (TABLE(N2212) -               QTAB 73
     1 TABLE(N1212))                                                    QTAB 74
          AMP122 = TABLE(N1122) + X1RAT * (TABLE(N2122) -               QTAB 75
     1 TABLE(N1122))                                                    QTAB 76
          AMP222 = TABLE(N1222) + X1RAT * (TABLE(N2222) -               QTAB 77
     1 TABLE(N1222))                                                    QTAB 78
          AMP11 = AMP111 + X2RAT * (AMP211 - AMP111)                    QTAB 79
          AMP21 = AMP121 + X2RAT * (AMP221 - AMP121)                    QTAB 80
          AMP12 = AMP112 + X2RAT * (AMP212 - AMP112)                    QTAB 81
          AMP22 = AMP122 + X2RAT * (AMP222 - AMP122)                    QTAB 82
          AMP1 = AMP11 + X3RAT * (AMP21 - AMP11)                        QTAB 83
          AMP2 = AMP12 + X3RAT * (AMP22 - AMP12)                        QTAB 84
          AMP = AMP1 + X4RAT * (AMP2 - AMP1)                            QTAB 85
          RETURN                                                        QTAB 86
          END                                                           QTAB 87
```

```
          SUBROUTINE PAGENO                                           PAGH  1
C     SUBROUTINE FOR NUMBERING THE PAGES AND IDENTIFYING THE RUN     PAGH  2
          COMMON P(10000), NTEGER(100), TABL4(2000,2),                PAGH  3
     1 TABL2(500,1)                                                   PAGH 31
          INTEGER DAY, YEAR                                           PAGH 41
          EQUIVALENCE (INTEGER(1), IDENT), (INTEGER(8), MONTH),       PAGH 90
     1 (INTEGER(9), DAY), (INTEGER(10), YEAR), (INTEGER(49), NPAGE)   PAGH 91
          WRITE (6,20) IDENT, MONTH, DAY, YEAR, NPAGE                 PAGH 10
   20 FORMAT(1H1,9X,6HRUN NO, I6, 10X,  6HDATE, I4, 1H/, I2, 1H/, I4, PAGH 11
     1 10X, 7HPAGE NO, I6 )                                           PAGH 12
          RETURN                                                      PAGH 13
          END                                                         PAGH 14
```

```
      SUBROUTINE   GAUSS2(N,M,EP,A,X,KER)                        GAUS 001
                   DIMENSION A(3,4), X(3,1)                       GAUS   2
      NPM=N+M                                                    GAUS 003
   10 DO 34 L=1,N                                                GAUS 004
      KP=0                                                       GAUS 005
      Z=0.0                                                      GAUS 006
      DO 12 K=L,N                                                GAUS 007
      IF(Z-ABS (A(K,L)))11,12,12                                 GAUS 008
   11 Z=ABS (A(K,L))                                             GAUS 009
      KP=K                                                       GAUS 010
   12 CONTINUE                                                   GAUS 011
      IF(L-KP)13,20,20                                           GAUS 012
   13 DO 14 J=L,NPM                                              GAUS 013
      Z=A(L,J)                                                   GAUS 014
      A(L,J)=A(KP,J)                                             GAUS 015
   14 A(KP,J)=Z                                                  GAUS 016
   20 IF(ABS (A(L,L))-EP)50,50,30                                GAUS 017
   30 IF(L-N)31,40,40                                            GAUS 018
   31 LP1=L+1                                                    GAUS 019
      DO 34 K=LP1,N                                              GAUS 020
      IF(A(K,L))32,34,32                                         GAUS 021
   32 RATIO=A(K,L)/A(L,L)                                        GAUS 022
      DO 33 J=LP1,NPM                                            GAUS 023
   33 A(K,J)=A(K,J)-RATIO*A(L,J)                                 GAUS 024
   34 CONTINUE                                                   GAUS 025
   40 DO 43 I=1,N                                                GAUS 026
      II=N+1-I                                                   GAUS 027
      DO 43 J=1,M                                                GAUS 028
      JPN=J+N                                                    GAUS 029
      S=0.0                                                      GAUS 030
      IF(II-N)41,43,43                                           GAUS 031
   41 IIP1=II+1                                                  GAUS 032
      DO 42 K=IIP1,N                                             GAUS 033
   42 S=S+A(II,K)*X(K,J)                                         GAUS 034
   43 X(II,J)=(A(II,JPN)-S)/A(II,II)                             GAUS 035
      KER=1                                                      GAUS 036
      GO TO 75                                                   GAUS 037
   50 KER=2                                                      GAUS 038
   75 CONTINUE                                                   GAUS 039
                   RETURN                                        GAUS
                   END                                           GAUS 040
```

```
      SUBROUTINE  GAUS21(N,M,EP,A,X,KER)                              GAUS 001
                  DIMENSION A(25,50), X(25,25)                        GAUS    2
      NPM=N+M                                                         GAUS 003
   10 DO 34 L=1,N                                                     GAUS 004
      KP=0                                                            GAUS 005
      Z=0.0                                                           GAUS 006
      DO 12 K=L,N                                                     GAUS 007
      IF(Z-ABS (A(K,L)))11,12,12                                      GAUS 008
   11 Z=ABS (A(K,L))                                                  GAUS 009
      KP=K                                                            GAUS 010
   12 CONTINUE                                                        GAUS 011
      IF(L-KP)13,20,20                                                GAUS 012
   13 DO 14 J=L,NPM                                                   GAUS 013
      Z=A(L,J)                                                        GAUS 014
      A(L,J)=A(KP,J)                                                  GAUS 015
   14 A(KP,J)=Z                                                       GAUS 016
   20 IF(ABS (A(L,L))-EP)50,50,30                                     GAUS 017
   30 IF(L-N)31,40,40                                                 GAUS 018
   31 LP1=L+1                                                         GAUS 019
      DO 34 K=LP1,N                                                   GAUS 020
      IF(A(K,L))32,34,32                                              GAUS 021
   32 RATIO=A(K,L)/A(L,L)                                             GAUS 022
      DO 33 J=LP1,NPM                                                 GAUS 023
   33 A(K,J)=A(K,J)-RATIO*A(L,J)                                      GAUS 024
   34 CONTINUE                                                        GAUS 025
   40 DO 43 I=1,N                                                     GAUS 026
      II=N+1-I                                                        GAUS 027
      DO 43 J=1,M                                                     GAUS 028
      JPN=J+N                                                         GAUS 029
      S=0.0                                                           GAUS 030
      IF(II-N)41,43,43                                                GAUS 031
   41 IIP1=II+1                                                       GAUS 032
      DO 42 K=IIP1,N                                                  GAUS 033
   42 S=S+A(II,K)*X(K,J)                                              GAUS 034
   43 X(II,J)=(A(II,JPN)-S)/A(II,II)                                  GAUS 035
      KER=1                                                           GAUS 036
      GO TO 75                                                        GAUS 037
   50 KER=2                                                           GAUS 038
   75 CONTINUE                                                        GAUS 039
                  RETURN                                              GAUS
                  END                                                 GAUS 040
```

```
                  SUBROUTINE PRINTR                                    PRNT   1
C           SUBROUTINE FOR PRINTING PROBABILITY FUNCTIONS              PRNT   2
                  COMMON P(10000), NTEGER(100), TABL4(2000,2),         PRNT   3
      1     TABL2(500,1)                                               PRNT  31
                  REAL  NT                                             PRNT  32
                  DIMENSION PPSI(100), PDPSI(100), FSILL(100),         PRNT   4
      1     PSIL(100), FRAC(100), EXCEED(100)                          PRNT  41
                  EQUIVALENCE (P(6), HOURS)                            PRNT  42
                  EQUIVALENCE (P(100), NT)                             PRNT  43
                  EQUIVALENCE (P(131), FSIL), (P(1001), PPSI),         PRNT   5
      1     (P(1101), PDPSI), (P(1TC1), PSIL), (P(1401), FRAC)         PRNT  51
                  EQUIVALENCE (P(6001), EXCEED)                        PRNT  53
                  EQUIVALENCE (INTEGER(11), NPSIL), (INTEGER(12), NPSILL)PRNT 6
                  EQUIVALENCE (INTEGER(49), NPAGE)                     PRNT   7
                  NPAGE = NPAGE + 1                                    PRNT   8
                  CALL PAGEHD                                          PRNT   9
                  WRITE (6,10)                                         PRNT  10
   10       FORMAT(/10X, 43HINTERNAL LOAD CUMULATIVE PROBABILITY FUNCTION )PRNT 11
                  WRITE (6,15)                                         PRNT  12
   15       FORMAT (13X, 4HLOAD, 5X, AHCUM PROB, 19X, 4HLOAD, 5X,      PRNT 121
      1     AHCUM PROB, 19X, 4HLOAD, 5X, AHCUM PROB)                   PRNT 122
                  DO  20 I = 1, NPSIL, 3                               PRNT  13
                  I1 = I + 1                                           PRNT  14
                  I2 = I + 2                                           PRNT  15
   20             WRITE (6,30) PSIL(I), PPSI(I), PSIL(I1), PPSI(I1),   PRNT  16
      1     PSIL(I2), PPSI(I2)                                         PRNT 161
   30       FORMAT (10X, 1P2E13.6, 10X, 1P2E13.6, 10X, 1P2E13.6)       PRNT  17
                  IF (HOURS) 39, 39, 31                                PRNT 171
   31             DO  32 I = 1, NPSIL                                  PRNT 172
   32             EXCEED(I) = 1000.0 * NT * PPSI(I) / HOURS            PRNT 173
                  NPAGE = NPAGE + 1                                    PRNT 174
                  CALL PAGEHD                                          PRNT 175
                  WRITE (6,33)                                         PRNT 176
   33       FORMAT (/10X, 45HCUMULATIVE NUMBER OF EXCEEDANCES PER 1000 HRS)PRNT 177
                  WRITE (6,34)                                         PRNT 178
   34       FORMAT (13X, 4HLOAD, 2X, 11HEXCEEDANCES, 19X, 4HLOAD, 2X,  PRNT 179
      1     11HEXCEEDANCES, 19X, 4HLOAD, 2X, 11HEXCEEDANCES )          PRNT 180
                  DO  35 I = 1, NPSIL, 3                               PRNT 181
                  I1 = I + 1                                           PRNT 182
                  I2 = I + 2                                           PRNT 183
   35             WRITE (6,30) PSIL(I), EXCEED(I), PSIL(I1),           PRNT 184
      1     EXCEED(I1), PSIL(I2), EXCEED(I2)                           PRNT 185
   36       FORMAT (10X, 1P2E13.6, 10X, 1P2E13.6, 10X, 1P2E13.6)       PRNT 186
                  WRITE (6,37)  HOURS                                  PRNT 187
   37       FORMAT (//10X, 8HBASED ON, F9.2, 6H HOURS)                 PRNT 188
   39             NPAGE = NPAGE + 1                                    PRNT 189
                  CALL PAGEHD                                          PRNT  19
                  WRITE (6,40)                                         PRNT  20
   40       FORMAT(/10X, 42HINTERNAL LOAD PROBABILITY DENSITY FUNCTION )PRNT 21
                  WRITE (6,45)                                         PRNT  22
   45       FORMAT (13X, 4HLOAD, 5X, 8HPROB DEN, 19X, 4HLOAD, 5X,      PRNT 221
      1     8HPROB DEN, 19X, 4HLOAD, 5X, 8HPROB DEN)                   PRNT 222
                  DO  50 I = 1, NPSIL, 3                               PRNT  23
                  I1 = I + 1                                           PRNT  24
                  I2 = I + 2                                           PRNT  25
   50             WRITE (6,30) FSIL(I), PDPSI(I), PSIL(I1), PDPSI(I1), PRNT  26
      1     PSIL(I2), PDPSI(I2)                                        PRNT  27
```

```
                  NPAGE = NPAGE + 1                              PRNT 28
                  CALL PAGEHO                                    PRNT 29
                  WRITE (6,60)                                   PRNT 30
      60      FORMAT(/10X, 24HCYCLIC LOADING FRACTIONS )         PRNT 31
                  WRITE (6,70)                                   PRNT 32
      70      FORMAT (19X, 4HLOAD, 5X, 8HFRACTION, 19X, 4HLOAD, 5X,  PRNT 33
        1     8HFRACTION, 19X, 4HLOAD, 5X, 8HFRACTION)           PRNT 34
                  DO   80 I = 1, NPSILL, 3                       PRNT 35
                  I1 = I + 1                                     PRNT 36
                  I2 = I + 2                                     PRNT 37
      80          WRITE (6,30) PSILL(I), FRAC(I), PSILL(I1), FRAC(I1), PRNT 38
        1     PSILL(I2), FRAC(I2)                                PRNT 39
                  WRITE (6,90) NT                                PRNT 391
      90      FORMAT(/10X, 19HTOTAL LOAD CYCLES =, F12.0)        PRNT 392
                  RETURN                                         PRNT 40
                  END                                            PRNT 41
```


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